SYSTEMS ANALYSTS
AND THE RESTRUCTURING OF WORK

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ABSTRACT

This thesis sets out to examine contemporary organisational restructuring. In particular it documents and examines the role of engineers and systems analysts in designing and delivering new technologies and work systems.

On the basis of fieldwork observations and detailed cross sectoral interviewing of over three hundred personnel in over sixty organisations, the thesis documents the kind of restructuring that is taking place and who is involved in the process. Whilst examining the role of trade unions, management and engineers within this process of restructuring the key focus is systems analysts - who hitherto, have remained a largely uncharted and under-researched group of workers. Through fieldwork, interviews and literature reviews the thesis highlights who systems analysts are and what is involved in the process of systems analysis and design.

The thesis, First, documents and offers a critical assessment of the process of business restructuring and some of the key attempts to theorise this process. Second, it documents and examines a series of methods, values and techniques which constitute a design culture, or referral point, from which engineers and analysts interpret what is in the organisations interest, make sense of their own work, pass judgement on their designs and assess their relationships to others involved in the design process. Third, through an analysis of the tools and techniques used for systems analysis and design the thesis demonstrates that there is a profound contradiction between, on the one hand, attempts to develop tools and

techniques to more accurately embody the social in the technical and, on the other hand, the influence which prevailing property relations and configurations of power have on the tools and techniques used in systems design. This influence is manifest in the continued existence of a software bottleneck and in system failure and user dissatisfaction. Fourth, the thesis highlights the nature of union involvement in the design process and demonstrates some of the key issues and concerns unions face in the 1990s. Finally, the thesis assesses a number of key attempts to analyse the class position of 'intermediate strata' and demonstrates, on the basis of fieldwork studies and interviews the class position of engineers and systems analysts and how this influences the types of technologies and systems these groups design.

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INTRODUCTION

This thesis examines the broad process of organisational restructuring and documents the role of systems analysts within this process. The rationale behind the research is that systems analysts constitute a largely uncharted group of workers and yet are central to the design and implementation of new information technology based work systems which organisations are introducing.

From the outset it was apparent that to build up an accurate picture of change and the role of analysts within it that not only would I need to deploy a methodology that enabled me to interview and observe analysts at work but one which also enabled cross sectoral analysis. This would allow me to capture the diversity of organisations systems analysts worked in from heavy engineering and manufacturing through to the financial services sector and public organisations. Further, the data gathering needed to be reflexive so that I could check and cross check my findings with informants in light of new data gathered and thus progress in both theoretical and empirical terms. Consequently, I examine a number of key groups and parties involved in the process of design and restructuring, namely trade unions, management, management and information technology consultants, systems analysts, systems managers and engineers. The rationale behind my focus on each of these groups is explained fully in the methods appendix. My concern was to build up a broad picture of the process of change and at the same time to cross refer accounts of this change. Focus on these groups facilitated this and gave me a detailed and rich picture of change and the role of various parties involved.

This thesis is based on extensive fieldwork and is reflexive in character. I did not enter the research with a particular idea or problematic. Rather, there were several ideas and problematics which were tested in the field and evaluated. Several theses emerged, the most important of which became my central thesis: that the culture, practices, values and methods of engineers and systems analysts demonstrates the ways in which engineers and systems analysts rationalise their designs and design activity and interpret what is `best' for organisations. The thesis demonstrates that not only do engineers and systems analysts exercise degrees of autonomy over the systems that get built but that they actively interpret, via a distinctive design culture, just what constitutes `capital's interest' and good or bad systems design.

The thesis is divided into six chapters in which I incorporate the findings of my fieldwork as they affect and implicate each of the groups I am concerned with. I have tried to maintain a balance in the chapters between my own empirical fieldwork data and the broader theoretical debates which are presented and discussed. My findings are used to assess the merits and weaknesses of these broader debates.

In Chapter One I demonstrate that much of the theoretical debate on information technology and the restructuring of work, with its emphasis on sweeping paradigm changes in manufacturing, business and broader society, is deterministic, teleological and out of touch with the changes I encountered in my research. My research indicates a far more incremental and contingent process and suggests that far from there being a sweeping transformation in the mode and methods of producing goods and services, rather, different organisational strategies reflect specific local contingencies, for example, type of product, nature of market, market position, or local industrial relations and labour market conditions etc. I demonstrate through my fieldwork data and through an evaluation of several key theories of manufacturing and organisational change that the rationale behind the introduction of new working practices and organisational cultures can be theorised differently. Rather than being the harbinger of a new age of organisation these practices are historically contingent, a reflection of key features of the contemporary historical conjuncture and balance of class forces.

In Chapter Two I focus on the work of engineers, for several reasons. First, many analysts either called themselves systems or software engineers or did some form of `engineering' as part of their broader job remit. Second, and more importantly, it became apparent that much of the `toolkit' systems analysts use has its roots in and is borrowed from engineering. Third, I was interested in documenting broadly the different work cultures which analysts and engineers experience - to show how possible variations in employment sectors (retracting manufacturing industry, expansionary service industry etc.) might have an impact upon engineers and systems analysts perceptions and practice. Whilst my interest in engineers was fuelled by these concerns, it increased once I started teaching engineers whilst still undertaking this research. My teaching included assessing syllabus content and how it met market demands and this prompted me to look in detail at engineers` values and methods. Consequently, Chapter Two using fieldwork data as well as literature reviews, documents a specific set of values and methods which engineers hold and which they utilise to rationalise their role in the design process and to assess the merits and weaknesses of the designs proposed and the types of systems which they build.

In Chapter Three I focus specifically upon the work of systems analysts and their role within the design process. Having established what systems analysis is, who does it, and the requirements in terms of education, training and skills, I document and assess the values and methods held by systems analysts which (as with engineers) serve to legitimate the analysts' role within the design process and which act as referral point from which analysts pass judgement on the validity of the systems they design. I establish that analysts exercise degrees of autonomy within the design process both in terms of the exercise of their own labour and in terms of their capacity to build systems which reflect their particular interests or world views. In this and chapters four and six I also draw out some of the similarities and differences between engineers and systems analysts in terms of practices, values and methods and highlight the different ways in which engineers and analysts perceive their work and their relationship to others involved in processes of design.

In Chapter Four I argue that there is a 'software bottleneck' in systems design. This reflects, in part, one of the fundamental contradictions of the capitalist mode of production - its socialisation of the productive forces, on the one hand, yet its constraint of these very productive forces, on the other, by the dominant set of property relations and configurations of power that flow from a system based on private ownership of the means of production. I examine some of the key solutions advanced to counter this bottleneck and highlight the autonomy analysts exercise within the design process. I show that the project team approach to analysis and design (favoured by most systems analysts and systems managers) signifies the power analysts and 'systems departments' can wield. The project team indicates that design needs to be conceived as a process of compromise. This is contrary to the content of analysts education, training and much of the literature of systems design which presents design as a science, uncompromising and value free. I argue that the project team approach is anti-democratic and needs to be so if 'system interests' are to be secured within the design remit. I also discuss the possibilities of analysts transcending dominant design paradigms rooted in class based systems, arguing that many systems perspectives reinforce an elitist view of the designer and serve to subjugate the user to the higher good of 'the system'. Where this view is not seriously challenged, by either workers or managers, it is likely that systems analysts will remain wedded to existing structures of power and authority within organisations.

In Chapter Five I extend debates on democracy within the design process by focusing on trade union involvement in this area. On the basis of interviews with national, regional and local union officers and shop stewards it is clear that union involvement in the design process is nominal. I argue that unions tend to hold a technologically deterministic position *vis a vis* technology and its design; this position, coupled to their commitment to collective bargaining and reformism, weakens their capacity to secure their members' interests within the design process. Consequently, many organisations have been able to take advantage of high unemployment, anti-trade union legislation and a favourable political climate to introduce new technology and new working practices largely unchecked. An alarming development is that not only are unions today further removed from involvement in the design process than at any time since the 1960s; but that they are becoming increasingly complicit in securing workers' acceptance of new designs and new working practices. This is because many unions, in a context characterised by plummeting memberships and fierce inter union competition for representation rights with employers, are prepared to sign away basic employee rights (for example, the right to strike) and, equally importantly, are expected to police all new agreements and to secure worker compliance to new systems as a matter of contract.

Chapter Six is concerned with the class position of engineers and systems analysts. I argue that none of the key debates offer an adequate account of engineers' and analysts' class position. The majority of engineers and analysts I studied are part of the collective labourer, albeit generally non-subordinate and not class conscious labourers. There are, however, notable exceptions, which are discussed. Likewise I argue, on the basis of themes developed in earlier chapters, that engineers on the whole (partly because they experience the effects of recession more directly than systems analysts) tend to be more critical of existing bases of power and authority and of government policy, than systems analysts. I also demonstrate how perceptions of class, power and authority have an impact upon engineers' and systems analysts' perceptions of their own labour and upon the types of systems which they design.

In the Conclusion I summarise my main research findings and indicate the ways in which the research contributes to and extends debates on design and technical change. I also discuss the implications of my findings for current research and practice and suggest ways in which the research could fruitfully be extended.

Finally, in the Methods appendix I discuss the philosophical approach underlying the research. I discuss why I chose to combine fieldwork observation and extensive cross sectoral interviewing techniques and I emphasise the qualitative and reflexive nature of the work. Details regarding the number and type of interviewee, fieldwork location, field practice, chronology of work, and analysis and interpretation of fieldwork data are discussed in the appendix.

The Contemporary

Restructuring of Manufacturing

Introduction

There has been widespread debate amongst politicians, managers and academics regarding the relatively poor performance of the British economy and the productivity of British industry (Coats & Hillard 1986). This has stimulated debates on manufacturing strategy and models of restructuring. Initially, many of these debates took an eulogistic 'follow Japan' approach (Ouchi 1981, Hayes 1981, Peters 1982) . More recently, these changes have been variously theorised as signifying an historical rupture with supposedly old and dated methods of production and the opening up of new production paradigms. These encompass either relatively simple shifts towards new systems of production (Piore & Sabel 1984, Atkinson 1985, Tolliday & Zeitlin 1986, Hirst & Zeitlin 1990) to more complex general statements about changes in the social relations of production and the broader social and cultural fabric of society (Murray 1985, Jessop 1988, Baudrillard 1988, Minc 1992, Handy 1995, Maffesoli 1995). The general impression is that we are entering a new historical stage, the apocalyptic dimensions of which are similar to those adumbrated by Marx[1].

In this chapter I focus upon four key theoretical debates concerning change and transformation in manufacture and society. These debates are:

1) Japanisation
2) Flexible Specialisation
3) Post-Modernism
4) Post-Fordism and Regulation Theory.

These debates are chosen because they encompass a variety of discourses on the nature, cause and likely outcomes of the contemporary restructuring of manufacturing. These debates are evaluated in light of my fieldwork data. The intention is to provide a theoretical framework from which to assess organisational change and the broader processes of restructuring. This will then serve as a framework to locate my research in subsequent chapters on the work of 'designers' and of the social relations surrounding the design, development and introduction of new technologies.

Follow Japan: Japanisation and Flexibility in Britain?

As many companies struggled to survive the increasingly competitive and recessionary environment of the early 1980s, attention came to be focused on Japan and the Japanese 'economic miracle' (Cross 1985). It is the relative success of certain Japanese companies and their seeming ability to ride out the worst of the recession that has prompted interest in Japanese working practices, organisational culture and society[2].

Monden (1981) argues that the innovative practices Japanese firms are introducing, in particular the 'just-in-time/Total Quality Control' (JIT/TQC) system of production, represents a revolution in work organisation as great as that of Henry Ford. According to Sayer

> Many features of Japanese manufacturing have been cited to explain its competitive success, for example, relations between industry and the state, between industry and banks, low wages, tame unions, workaholism and the catch all category of Japanese culture (1986, 43-44).

Whilst recognising the importance of these factors in accounting for overall Japanese economic success Sayer nonetheless wishes to stress the 'Just-in-Time/ Total Quality Control' system as the decisive variable securing Japanese corporate success and in particular to emphasise that many of these practices are 'exportable'

> given the effect of the law of value in enforcing the adoption of the most productive techniques among competitors, they are already diffusing outside Japan (1986: 43).

Sayer stresses that these Japanese innovations

> represent a radical departure from conventional western managerial wisdom, yet in common with previous managerial and process innovations they involve the search for time economies in the circulation of capital and for new ways of extracting surplus value (1986: 44).

Whilst recognising that the particular organisational forms of capital bear the imprint of the particular social formations in which they develop Sayer (1986) nonetheless anticipates that these practices will become widespread as the 'operation of the law of value' penalises those firms that do not adapt and innovate and likewise reward those that do.

Sayer contrasts the Japanese 'JIT/TQC' system with what he describes as the western 'just-in-case' (JIC) system

> The 'just-in-case' system is a shorthand for a common bundle of characteristics of western industrial capital. These include particular approaches towards volume and specialisation of production, flexibility and demarcation, skills, quality control, bureaucratisation of procedures and relationships between groups, management techniques, innovation and the labour market....in many respects JIC resembles 'Fordism'(1986: 46).

The JIC system is characterised as one of high volume production of standardised commodities, in which competitive success is tied into low unit costs and economies of scale in which production is essentially mass production using standardised dedicated technologies and labour processes and in which the ultimate imperative is the 'getting of metal out the door' (Abernathy *et al* 1983).

This system is perceived by a variety of theorists (Kern & Schuman 1989, Piore & Sabel 1984, Atkinson 1986, Adler 1985, Tolliday & Zeitlin 1986) as having a number of key drawbacks:

> 1) The system is geared towards uniformity and standardisation of products and is therefore perceived as unresponsive to changes in the market.
> 2) Focus upon output and the speeding up of machines and individuals creates serious imbalances between the various aspects of the line.
> 3) Large inventories and buffer stocks are expensive in terms of interest charges, storage and monitoring costs and wastage when model specifications change (Estall 1985).
> 4) Rejects and defective parts or processes tend to be concealed in buffer stocks which enable one to get another part from store rather than get the 'build right first time'.
> 5)'Testing quality in' is far more expensive than 'building it in first time'.
> 6)The JIC system generates a deep vertical hierarchy of control which is both costly and unwieldy, acting to curb employee commitment and slow down innovation and communication (Clegg 1992, Handy 1995, Piore & Sabel 1984, Atkinson 1985, Thompson 1991).

By contrast Sayer argues that the 'JIT/TQC' system prevalent in Japan is a way of

> Organising the immediate manufacturing labour process and buyer-supplier relationships between firms, but it is [also] normally surrounded and supported by a wider set of practices regarding skills, management-labour relations and labour market conditions (1986: 51).

The key features of this system are:

1) The reduction of set up times of machines assisted by close collaboration between management, process engineers and shop floor workers (Schonenberger 1982).
2) The elimination or reduction of buffer stocks which are seen as an indication of waste and 'inefficiency' stemming from poor line balance, production problems, idle time, surplus workers, excessive equipment capacity and insufficient preventive maintenance (Sugimori *et al* 1977).
3) Total quality control and a get it right, defects free manufacture, first time round (Ohno 1982).
4) Workers with high behavioural skills, cooperativeness and self-discipline (Sayer 1985, Littler 1982, Suzaki 1985).

The most startling feature of the JIT system is that instead of producing at maximum volume in anticipation of market demand production now takes place only as and when needed. Workers at the end of the line are given output instructions and they instruct the workers immediately upstream to produce the parts they will need just-in-time, likewise these latter workers in turn instruct workers upstream from them to produce just-in-time and so on (Sayer 1986).

Instructions between workers can be communicated by means of tags or boards called 'kanban'. The whole system is a 'pull' rather than 'push' system whereby the kanban system orchestrates diverse activities into a flow line, markedly reducing planning, information handling and supervision costs and increasing the utilisation of capital (Ohno 1982).

Whilst the kinds of machinery used need not be very different from those used in the JIC system, the layout of the factory has to be changed radically:

> For example, under the JIC system lathes are clustered in the factory and operated by workers specialising in such skills. This contrasts with a layout oriented to production flow, where equipment is in line with material flow - the common approach in Japan (Suzaki 1985: 14).

For manufacturers to get most benefit from the JIT system a system of supplier networks needs to be generated. This makes for reductions in expensive materials handling equipment, factory space, storage/transportation and labour costs. Close management surveillance, co-operation and overlapping ownership between core companies and their suppliers is a key feature of JIT in Japan (Altshuler *et al* 1984). Crucially JIT depends on a set of labour market conditions and practices which include multiskilling, flexible working and job rotation along with simple payment systems to facilitate this. Low turnover of managers and key core workers and engineers on the shop floor is also seen as critical as is the need to zero defect manufacture achieved through quality circle, employee commitment to quality and self inspection and tight supplier control (Sayer 1986).

Those aspects of the Japanese system that the firms I studied were trying to adopt were Just-in-Time and Total-Quality-Control. This necessitated experiments with labour market segmentation and the introduction of new working practices and contracts. These tended to take the form of labour 'flexibility' strategies, in particular attempts to overcome 'restrictive practices' and 'unwieldy job demarcations' and to initiate both single union agreements or some broader general union agreement to quality and flexibility. Likewise some firms were seeking to tighten up their supplier base and seek joint contracts, the explicit aim of which is to achieve 'defect free manufacture', stock reduction and quality. Thus one Production Manager argued:

> Our company is initiating major changes in working practices ... in particular to overcome demarcation but also to instil responsibility with the workforce for quality. Our supplier base has also been extensively rationalised and contracts are awarded on a basis of preferential supplier status - those firms who meet our quality standards consistently and who reorganise their own production along similar lines to ensure defect free components will be given the contracts [the] key to all this has been a change in attitude on the part of the workforce and the unions ... and I think obviously Government policy has facilitated this (Production Manager, Multinational Car Manufacturer, England).

However, whilst a number of firms I studied were introducing JIT/TQC practices the majority were more or less carrying on as usual. Indeed, diffusion of JIT outside Japan has been slow, possibly because competitive advantage in Japan also derives from unique cultural features, close and favourable relationships with the state and financial institutions and tight supplier bases (Briggs 1987, Sayer 1986, Halliday 1976) which act to impede the 'law of value' in generalising the Japanese model abroad.

Most managerial literature on Japan tends to ignore these factors. A number of consultants and managers I interviewed shared this uncritical stance towards Japanese manufacturing practice:

> You've got to hand it to the Japs they know how to work together ... co-operation and flexibility are the key to their success ... (Consultant, Major UK Consultancy, Scotland).

> What we need is more co-operation and less infighting and interdepartmentalism ... the Japanese have got it sussed with their emphasis on harmonised working practices and team working (Personnel Manager, Japanese Electronics Company, Wales).

However, what is often eulogised as Japanese experience (Ouchi 1981, Schonberger 1983, Hayes 1981) is, in fact, a received model. As Ackroyd *et al* (1987) argue, it is not as easy to reproduce this or that particular Japanese trait or practice, as many practising UK managers and consultants apparently believe. Japan has its own unique historically determined class structure, labour market, industrial relations, culture, values and particular structuration of capital (Halliday 1975, Littler 1982, Briggs 1987) which, whilst conditioning the high levels of profitability of key Japanese corporations, nonetheless have their own specific drawbacks and contradictions (Lane 1987).

However, not all managers I interviewed were impressed by the 'Japanisation' discourse; indeed, a few were quite critical of Japanese work methods:

> I am totally unimpressed with the Japanese companies I have visited. They are ham strung by red tape and the rule book ... they are too rule bound and too inflexible. I don't think they are either better run or have better work relations than we have (Managing Director, Major UK Lighting Company, Wales).

Another drew out the possible weaknesses of the JIT system of production so predominant in Japan:

> Britain is not Japan, we do not have the same industrial relations ... we do not have the same culture, control or, indeed, ownership of our supplier companies as do Japanese corporations ... there isn't the same State support for industry ... JIT in Britain is risky (Production Manager, Major White Goods Manufacturer, Wales).

Thurley (1987) argues that there is a considerable gap between the ideological level at which so much of the debate is carried out and the realities of institutional practice and human behaviour where decisions are taken largely for pragmatic reasons. My own research confirms that this gap is particularly evident when one examines the practice of Japanese management in subsidiaries operating in this and other countries[3]. The range of employment practices utilised are, in many cases, little different from those of UK, American, or European firms. Several Japanese companies I studied were, for example, taking advantage of cheap female YTS labour, with management recognising, albeit when pressed, that this was one reason for investment, another being access to European markets. Franko and Dunning (1986) indicate that successful Japanese firms operating abroad, are very often exploiting acts of omission in the host countries industrial policy, investment strategies and domestic competitiveness rather than gaining advantage from superior management practices.

A number of union officials I interviewed, pointed out that most Japanese firms operating in Britain were either 'low tech', or 'no tech'; operating here to get round EC restrictions and to take advantage of cheap labour and favourable tax grants:

> Far from this company being innovative in its working arrangements I have to admit it is less progressive than many of the American or Swedish companies we have agreements with ... if you ask me all the company was wanting here was cheap mass assembly ... take a look its all female and YTS labour ... core components are shipped in from the parent company ... We are just assembly the companies just getting round EEC legislation on imports at the lowest cost in terms of investment in plant and personnel (Shop Steward, Japanese White Goods Manufacturer, Wales).

Dunning (1986) argues that where Japanese companies have invested on a large scale, for example Nissan in Sunderland, this investment has had a stimulating effect on competitors. Ford's 'After Japan' program, is cited as the most obvious example of a traditional Taylorist company, reassessing its work practices in response to supposedly superior Japanese practice (Giles & Starkey 1987).

However, the impetus to change at Fords and in many of the companies I studied does not so much come through an overnight conversion of management to the new gospel of Japanisation but is rather the result of reassessments of long standing internal problems:

> In particular - poor productivity, inconsistent quality, poor labour relations, high overheads and an inability to consistently meet production schedules (Systems Manager, Multinational Car Manufacturer, England).

A number of managers I interviewed argued that the increased interest in flexibility owes more to the general intensification of competition, favourable legislation and the need to secure short term cost savings, than to a more thorough going conversion of UK management to a new business creed:

> We have gone down the road to JIT and total quality management after careful consideration over a number of years of the rigidities inherent in mass production...In the sixties at this very site we pioneered work in job rotation and job enlargement, an objective here was to improve quality through enriching operator life and getting commitment to personal quality ... but recession hit and internal power struggles within the corporation over investment strategy and ... use of robotic and mechanised driven solutions to quality overrode these experiments. Obviously we also had to deal with increasingly militant labour organisations ... it was getting out of hand ... I could see the current strategy unfolding even then in the early seventies as senior executives looked for a solution to not only quality and cost savings but to the labour problem ... so we were quite aware of this and developing our own response well before the public debates on JIT, TQM and Japanese management (Production Manager, Multinational Car Manufacturer, England).

I found that typically management is experimenting with a variety of strategies of work organisation. In particular, a number of companies in my studies, are trying to internalise the market: that is, make workers directly accountable and responsible for their own work, via both utilisation of surveillance technology and a subverting of traditional union structures and negotiating machinery. 'Quality circles', 'Quality teams', 'Tiger teams' and a new emphasis on 'harmonisation' and 'corporate teamworking' may serve to weaken class solidarity amongst workers and tighten managerial control over production. One Personnel Manager candidly states:

> Let's be frank ... no one around here is naive enough to think we could have achieved any of this [harmonised work cultures and greater flexibility] had it not been for Thatcher and the changed attitudes she has conveyed ... I'm not a 'faddist' I don't believe any of the nonsense about harmonisation ... It might not even last much longer ... it's days will be numbered with a changed political climate (Personnel Manager, Software Manufacturer, Wales).

Friedman (1977) argues that management's are adopting new strategies of 'responsible autonomy' and 'flexibility' in an attempt to harness the adaptability of labour-power by giving workers leeway and encouraging them to adapt to changing situations in a manner beneficial to the firm. Japanisation, broadly defined, is seen as part of this overall strategy, as management supposedly seek to move away from the tight, costly, bureaucratic and delimiting control strategies of Taylorism and Fordism. However, my research would caution against such bipolar presentations of shifts in working practice. A number of companies I studied were actually doing the reverse by abandoning responsible autonomy type strategies and reintroducing strict Taylorism, indeed, primitive Taylorism:

> Ten years ago, we were experimenting with all kinds of practices, including job enrichment, job enlargement, improved facilities, devolving more decision making to operatives, in an attempt to liven up their work ... We had to, as did many companies round here, because frankly, labour turnover was abysmal [and] our training policy was in tatters ... People just were not prepared to do the job ... Nowadays people are more grateful ... [and] they are grateful to have any job, let alone interesting, rewarding jobs ... Yes we've ditched most of our earlier experiments ... It's probably more like the 1950s in here now than the 1990s (Production Manager, White Goods Manufacturer, Wales).

Friedman's identification of western management strategy with Taylorist control repeats Braverman's (1974) error, of treating direct control as the theory and practice of capitalist control over the labour process. Companies, in short, are pursuing a variety of strategies to raise profitability, including moves towards greater flexibility, tighter control and routinisation. I found that even in the same firm ostensibly contradictory policies can be pursued, for example, tighter control and Taylorisation of administrative, managerial and design grades and possible moves toward greater autonomy, or flexibility of production workers, utilising reprogrammable 'flexible' technologies. Alternatively, the reverse may happen and firms may be re-Taylorising shop floor work whilst, at the same time, introducing the latest reprogrammable technologies and Japanese style management practices. This is exactly what one large automotive components manufacturer was doing:

> We used to be very craft based [with] lots of craftsmen ... utilising very personalised machinery [and] building in small runs for a whole range of customers ... We used to manufacture a whole variety of components here ... so many I lost count ... Now we have rationalised our customer and product base [and] will be introducing new technology and will have our latest dedicated lines up and running by May 1992 ... If you ask me we've gone back to Henry Ford's principle, not away from it ... and I mean at every level of the organisation (Production Engineer, Automotive Components Manufacturer, Wales).

Ackroyd (1987) and Pollert (1989), argue that British firms are not attempting to introduce Japanisation *per se* but attempting to adapt to changed economic and political conditions, without relinquishing established bases of profit, power and influence. The essence of manpower flexibility, underlying many of these changes, is the pliability of working arrangements, or the ability of management to adjust quantity, composition, function and intensity of labour inputs to changing demands and requirements. Where firms are attempting to introduce flexibility, they are doing so, invariably, to reduce labour costs, increase productivity and improve quality.

Flexible Specialisation

The model of flexible specialisation advanced by Piore and Sabel (1984), Atkinson (1985), Tolliday and Zeitlin (1987) and Hirst and Zeitlin (1991) has achieved wide currency. Pollert (1987) argues 'that its appeal lies partly in its graphic dualist boldness and partly because it appears to integrate a number of processes' (1987: 32). The model essentially postulates two kinds of organisational flexibility: first, functional flexibility which refers to the crossing of occupational boundaries and more recently multiskilling of core workers; and, second, numerical flexibility which refers to a firm's capacity to adjust labour force levels rapidly via part-time, temporary and subcontracted labour, commonly referred to as 'peripheral' labour.

The figure below shows the structure of a flexible firm.

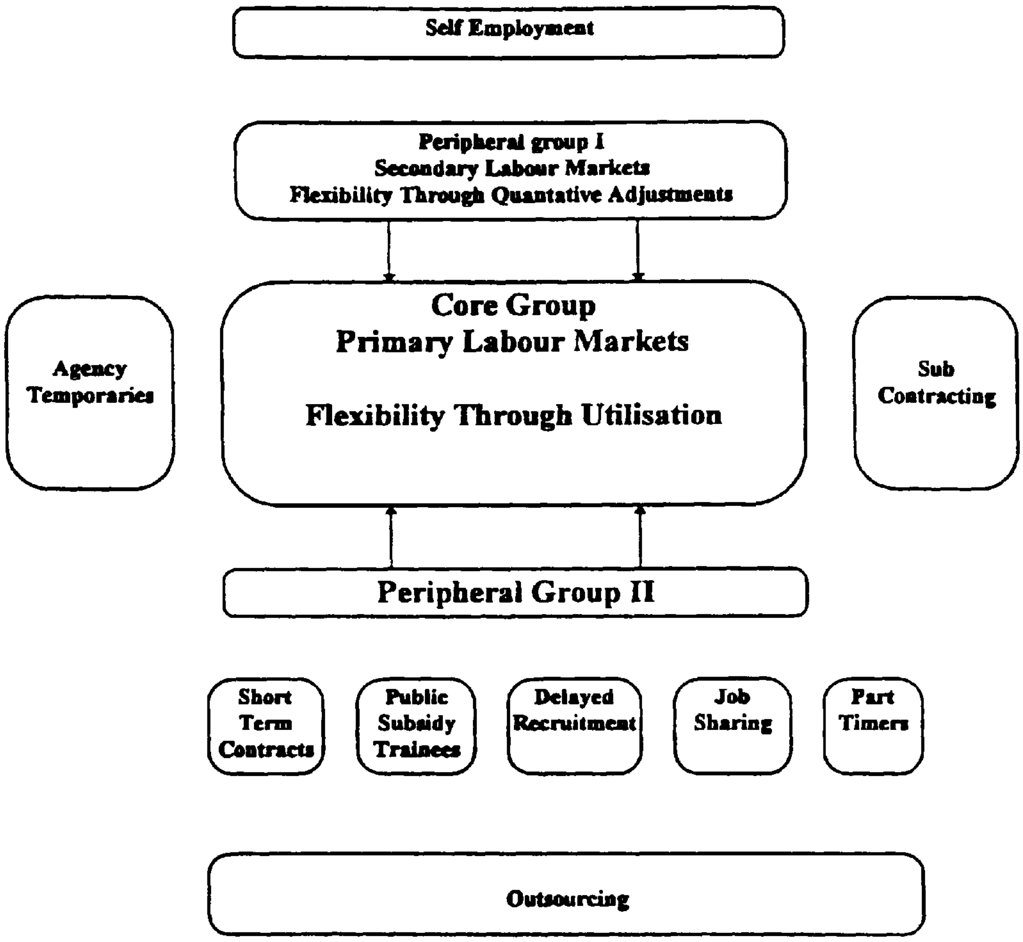


Figure 1. Flexible Firm

Coinciding with this core-periphery distinction in the labour market Atkinson (1985) and Piore and Sabel (1984) distinguish between core and peripheral organisations. They argue that flexible work situations will come to characterise the core whilst Fordist mass production intensifies in the periphery (Goldthorpe 1985, Christopherson & Storper

1989, Harrison and Bluestone 1988) possibly leading to a second industrial divide (Piore and Sabel 1984).

Central to the arguments of Piore and Sabel (1984) and Kern and Schuman (1989) is the notion that management's are redefining their labour problem, as they realise the futility of Taylorist management methods in the face of intensified Japanese competition and changing work attitudes. The key theme of the flexible specialisation thesis, as Wood (1989) points out, is the insistence that management are, or should, break with past orientations of control and intensification of work and seek to reverse tendencies towards ever more detailed divisions of labour.

The central building block of flexible specialisation is its distinction between mass production and craft production. Mass production is usually defined by Flexible Specialisation theorists, as the manufacture of standardised products in high volumes, using special purpose machinery and, predominantly, dedicated routine unskilled labour. Conversely, flexible specialisation is presented as a system of manufacture of a wide and changing array of customised products using flexible, general purpose machinery and skilled adaptable workers (Hirst & Zeitlin 1991).

According to Hirst and Zeitlin (1991), neither mass production nor flexible specialisation are inherently superior to the other, rather, each model is theoretically capable of generating a virtuous circle of productivity improvement and economic growth. Flexible

Specialisation theorists are quick to stress however, that the practical realisation of either model is contingent on institutional regulation at a micro and macro level. Thus Atkinson (1986) and Atkinson and Meager (1986), argue that in Britain, the drive to full flexibility is impaired by short sighted government policies, insufficient spending on education and training, incorrect monetary policies and a management culture still steeped in 'tough boss' Taylorist attitudes. By contrast Kern and Schuman (1989) argue that Germany has an almost fully flexible manufacture.

The flexibility thesis suggests a broadly favourable view of industrial relations which challenges ideas of work degradation and presents an alternative counterpoint to Braverman's thesis that deskilling is a central part of the capitalist labour process. Piore and Sabel see flexible specialisation as a way out of the supposed crisis of Fordism and the alienating conditions of the assembly line. They assert that flexible specialisation stresses the potential of new technology to upgrade skills and 'open up long term prospects for improvement in the conditions of working life' (1984: 278).

One of the main weaknesses of 'flexible specialisation' is its oversimplification of work organisation into two discreet historical paradigms: Fordist based mass production and flexible specialisation (Metcalf 1986, Pollert 1987). One must question the whole notion of sweeping flexibility and a shift away from supposedly Taylorist or Fordist mass production. The Warwick IRRU Company Level and Industrial Relations survey, covering multi-establishment companies with over 1000 employees in six sectors, found that the majority of firms reported no significant changes in policy towards the use of temporary labour contracts (Marginson 1988). Even more importantly, the NEDO survey, which set off with the intention of proving the flexible firm model by examining changing managerial practices, concluded that it was not possible to make definitive statements about which direction firms were moving. Reporting the result of the NEDO Report, Atkinson and Meager (1986) ask 'Is flexible specialisation just a flash in the pan?'. Their own research evidence forced them, as Pollert notes, 'to dilute their claims of an overarching strategic shift, or of flexibility as the central management aim' (1987: 32).

Rather than positing two dichotomous models of development, Flexible Specialisation theorists should recognise that capital has always had a variety of strategies of labour market segmentation, i.e. gender, race, age, skill, etc., and a repertoire of managerial strategies (Friedman 1977, Thompson 1989, 1995, Burawoy 1986, Edwards 1979) the use of which can be contingent upon a variety of factors, for example labour militancy, training programmes, labour market skills, specific level of capital accumulation, etc.

Sayer (1980), Clark (1988) and Bonfeld (1987) see flexible specialisation as being far more circumscribed than Flexible Specialisation theorists in that they do not see evidence of sweeping changes away from mass production and towards niche production. They also theorise those changes that are taking place differently, for example, perceiving flexible specialisation as an attempt by managers, not only to reassert control over the labour process but also to win productivity and quality improvements within essentially Taylorist and Fordist systems of manufacture.

This point was brought home by several respondents in the companies I studied. They stressed that they were utilising new 'flexible' technologies and work practices (e.g. multiskilled, or more accurately, firm specific skilled labour in quality teams and within JIT manufacturing systems) not in an attempt to abandon Taylorist or Fordist methods, but to address some of the problems encountered with them, i.e. consistently poor quality, high labour turnover, absenteeism, costly supervisory hierarchies and bureaucracies[4].

I asked the Systems Manager of an automotive components firm in Wales whether he thought the firm's recent commitment to JIT and flexibility involved a shift in managerial philosophy away from traditional Taylorist methods. I also enquired whether or not the company was going down the 'niche' market route extending its customer base and offering greater product diversity.

> We decided to go for a low stocks JIT system ... and to reorganise our lines to suit ... In the past few years we've brought in CAD, Robotics, reprogrammable CNC machine tools and experimented with quality teams. We will be striving for a full CIM system ... Ironically we are focusing our lines and becoming more dedicated, as our computer systems and business operations link in ever more closely to those of our major customers, who often insist that we adopt their methods ... To be frank, we used to knock out the odd components here and there for a wide range of car manufacturers big, small and down right quirky but

> we've become far more dedicated now, our product range has narrowed, our lines are more dedicated ... and I suppose diversity of work on the lines too ... [and] ... maybe ... also the skills component of workers on the line ... I know a lot of the older ones complain more now about tedium (Systems Manager, Automotive Components Manufacturer, Wales).

I asked the Production Manager of an electrical components company in Scotland whether or not he thought the firm's commitment to JIT and high levels of automation had meant a radical change in the way labour was utilised in the organisation:

> What we are witnessing is more a changed culture than an actual change in labour utilisation ... All I can say is production here, is essentially mass production of standardised components ... The greatest change has been JIT and reduction of inventories and this was preceded by a massive campaign in the company, emphasising quality and the need for everyone to pull together ... it's the culture again ... More than anything, all of us are aware of the fragility of our jobs. (Personnel Manager, Electrical Components Manufacturer, Scotland).

As Block (1985) argues, the notion of flexibility is unclear. A variety of forms of labour utilisation coexist under capitalism and they always have done. By contrast, Flexible Specialisation theory tends towards a nostalgic reification of craft labour, not only as the medium through which individual workers will free themselves from the tedium of the line but also the medium through which unprofitable firms will secure profitability. Such analysis oversimplifies both the causes of worker alienation and the conditions necessary for profitable production. It also reduces the repertoire of managerial concerns to only one: labour flexibility. In short, flexibility may be no more the key to profitability than any other managerial strategy, such as economies of scale, good advertising, good product design, product development, niche marketing and attractive pricing, etc..

Piore and Sabel assert that Flexible Specialisation offers labour new hope: the hope of being reskilled and respected within a high trust work relation often goes against actual practice. Cohen (1987) and Shaiken (1984) argue that management may, through strategies of labour market segmentation and ending of internal job demarcations, be reasserting much of the control over labour which it lost in the seventies. This can be a very high risk strategy. My own research indicates the concern many managers feel over the fragility of recent organisational and technological changes:

> Headlong rushes into ad hoc computerisation flexible work systems and JIT may prove unwise ... These systems are very fragile [from] a pulled plug, a blown fuse, a change of attitude ... and we are put in a delicate position (Personnel Manager, Major White Goods Manufacturer, Wales).

JIT and Flexible Manufacturing Systems (FMS) are often seen as high trust manufacturing environments requiring close collaboration and excellent working relations between both workforce and suppliers. A significant number of managers pointed out that JITs success depends on having the 'right' political climate because any stoppage of work, be it in the supplier, or manufacturing base, will have disastrous consequences on work in progress. Equally, concern was voiced over the issue of flexibility and new harmonised work cultures:

> The whole point about flexibility is that it is tied into productivity and quality performance indicators ... In turn for accepting new agreements on working practices ... and in particular reskilling and weakening of job demarcations ... our workforce expect to earn better pay and have at least the same if not better conditions ... management hang everything on being able to deliver consistent pay improvements ... through productivity and quality gains ... What happens if they can't do this ... because the market cannot absorb any more capacity or your competitor is using cheaper labour or securing greater productivity? ... [It can be] a recipe for disaster ... Look at Nissan. They promised the earth and now they are facing a three day week ... Imagine how the workforce must feel given management's insistence that their flexibility strategy was right (Personnel Manager, Heavy Electrical Engineering Company, Scotland).

Piore and Sabel's flexible specialisation thesis offers a model in which workers and managers unite for the common good of the organisation. It is a model which downplays antagonism of interest between workers and managers. Dankebar (1988) draws out the reformist implications of this position, whilst, at the same time, highlighting the fragile social consensus that this form of work system may rest upon. For employers, flexible specialisation openly politicises the manufacturing process, in the sense that the whole system rests on high trust quasi-democratic work relations and upon an internalisation of market values. This generates competition between workers in quality and production teams, bolstering the maintenance of divisions in terms of pay, status, and responsibilities between core and peripheral workers. It also persuades workers to accept the need for continual productivity and quality increases via competitive quality teams, cultural symbolism, and a suitable array of surveillance and shop floor data capture technology[5].

Post-Modernism: From Weber's Iron Cage to Gergen's Clouds?

Debates on 'post-Fordism' and 'flexible specialisation' assert rupture with old modes of production and the emergence of sweeping new production paradigms; likewise in 'post-modern' organisational theory we find a new discourse proclaiming organisational revolution and radical restructuring. Gergen (1989) captures the mood of this discourse when he asks: why must we conceive of organisational cultures as structures rather than clouds or tents? He argues that modernist discourses have straight-jacketed our emotional and conceptual frameworks in Weberian notions of rationality and efficiency.

Clegg (1990: 2) argues that 'organisational theory is a creature of modernity', based on notions of bureaucratic control over a detailed division of labour that is no longer dominant. Gergen (1989) stresses that organisational theory has committed the 'modernist' sin of belief in the 'narrative of progress': scientific management and systems approaches, in particular, with their emphasis on the 'rational' design of organisations, pursuit of organisational 'efficiency' and the minimisation of uncertainty are seen as key sinners (Thompson 1991).

In contrast to the narrative of 'modernism', with its emphasis on the rational understanding and essential knowability of 'nature', post-modernism stresses the 'fundamental uncontrollability of meaning' (Parker 1990). Certainty becomes uncertainty and reality does not exist outside of multiple discourses (Foucualt 1977, Keane 1988, Baudrillard 1988). Thus, Clegg (1990) stresses the breakdown of dominant Taylorist divisions of labour and an abandonment of Weberian rationality within organisations. Parker (1990) sets discussion of 'post-modern' organisations within a framework of societal breakdown with the emphasis on cultural fragmentation and organisational pluralism. Mulgan (1989) talks of a shift from 'strong' to 'weak' organisational power, as information technology facilitates a more decentralised, plural and democratic exercise of power; whilst Bauman emphasises a new cultural climate of heterogeneity, indeterminacy and disorganisation leading to a general impression of 'disorientation and chaos' (1989: 793).

Post-modern discourse also draws on the work of 'post-industrial society' theorists (Touraine 1974 and Bell 1984) and futurologists (Naisbitt 1982, Toffler 1980) with their advocacy of a paradigm shift away from production to consumption and leisure (Callinicos 1989). Finally, there is a strong technological determinist undercurrent within much of the post-modern discourse: Mulgan (1989), Clegg (1990), Naisbet (1983) and Handy (1990) all present technology, and specifically, information technology, as the initiator of organisational changes.

The modernist organisation according to Clegg 'may be thought of in terms of Weber's typification of bureaucratised, mechanistic structures of control, as these were subsequently erected upon a fully rationalised base of divided and deskilled labour' (Clegg 1990: 177). By contrast, Hydebrand (1991) argues that the 'post-modern' organisation is small, or located in small subunits of larger organisations. It is service orientated, its technology is computerised, its division of labour informal and its management structure decentralised, eclectic and participative.

Modern Organisation	Post-Modern Organisation
Market stable markets, mass consumption producer dictates supply Competition one of scale needs regulating	**Market** Dynamic markets, niche markets consumers dictate supply competition one of scope self regulating
State interventionist/Keynsian	**State** minimalist/monetarist
Technology dedicated special purpose, assembly line	**Technology** universal, reprogrammable, flexible
Work organisation Taylorist, detailed division of labour	**Work organisation** craft, multi-flexible
Management tasks Supervision, planning and control	**Management tasks** Facilitive, eclectic and participative
Company size and structure large corporations hierarchic bureaucratic centralised mechanistic structures of control	**Company size and structure** small companies or franchises cultural networks information technology networks de-centralised informal division of labour

Table 1. Regulative Context and Characteristic Features of a 'Modern' and 'Post-Modern' Organisation.

The 'post-modern' organisation is held to be post-bureaucratic. Strong cultural and information technology networks are the cement which holds them together (Berg 1989, Heckscher 1994). The notion of post-bureaucratic organisation fits in with broader societal changes argued to be taking place by post-modernists. Thus Baudrillard (1983) highlights the breakdown of conventional wisdom's and practice as we enter a new age of 'hyper reality' in which fact and fiction, right and wrong, become increasingly unknowable, increasingly distorted through what Marxists would conceptualise as an attenuated state of commodification, reification and alienation. Lash (1988) refers to the erosion of social boundaries and an all purpose reversal of the division of labour. Added to this, we get a far broader argument that 'post-modernity' represents a liberalisation of society and a democratisation of organisational power (Clegg 1990, Handy 1995).

The message is that companies can no longer afford the burden of monolithic bureaucratic and costly structures and procedures. Post modern organisations are argued to be in a process of 'reverse thrust', seeking consciously to decentralise and downsize as they are now 'prepared to live with structural chaos and ambiguity' (Berg 1989: 207). Underpinning much of the 'post-modern' discourse on organisational change is the notion of mass pluralisation within society. Post modernists argue that collective class consciousness is drowning in a sea of commodity fetishism (Baudrillard 1989) and a rediscovery of 'individualism' or `tribalism' (Murray 1988, Maffesoli 1995). This, in turn, is perceived to support shifts within organisational practice towards 'democratisation' and 'high trust' work relations (Clegg 1990). The new emphasis within 'post-modern' organisational discourse is on the role of managers as 'facilitators' and on the importance of symbols and culture as both organisational levellers and 'efficiency' enablers (Cooper 1989).

Drawing on post-industrialism's end of ideology thesis, Lyotard (1984) dismisses the grand scientific discourses of Western society arguing that with the computerisation of society the medium exists for the creation of a new discourse of plurality and openness within organisations. Likewise, Burrell (1988) anticipates a star role for computer architecture as an 'organisational democratiser' rather than Benthamite Panoptican.

Thompson (1991) stresses that whilst Bell was wary that the hedonistic excesses of consumerism would destabilise post-industrial society, Bauman (1988) sees it as sweeping away the systems problems. The market brings with it the pressures and pleasures of seduction by the symbolism of spending power. Thompson (1991) argues that, for many post modernists, so effective is this seduction that capital is able to dispense with repression and much of its apparatus of control and the need for political legitimisation and ideological domination.

The notion of impermanence and change Marx used to highlight social relations under capitalism is rearticulated and given a new twist by many former radicals now turned post-modernists. Callincos (1989), for example, argues that, above all else, post-modernism, in its origins, reflects the disillusionment of the 'generation of' 68 and the 'left' aspirations that were shattered with the defeat of the general strike in France. Over twenty years later, with Western capitalism seemingly stabilised under the leadership of the New Right, the retreat of the generation of 68 from the revolutionary beliefs of their youth has gone even further. As Harman remarks, 'If the fashion in 1968 was to drop out and to drop acid now, apparently, it is to drop in and drop socialist politics (1989: 8).

A principle feature of post-modern discourse is its aestheticism inherited from Nietzche and reinforced in Derrida's and Foucault's attempts to articulate the philosophical implications of modernism. Sontang (1980) has argued that aestheticism involves an attitude which is neutral with respect to content. This drift towards aestheticism accorded with the cultural mood of the 1980s a decade obsessed with style. Theorists of post-Fordism captured the differentiation of markets and rise of designer brands and consumption based lifestyles. In various aspects of life, as Callinicos argues:

> One could detect a similar association of certain kinds of consumption with forming oneself into a particular kind of person. Among the most important was a narcissistic obsession with the body, both male and female, less as an object of desire than - when disciplined by diet and exercise into a certain shape - as an index of youth, health, energy and mobility. This stylisation of existence to borrow Foucault's phrase is surely best understood against the background, not of New Times, but of good times for the new middle class, a class which found itself in the 1980s with more money in its pocket and easier access to credit, without the pressure to save which the old petty bourgeoisie was subject (1984: 169).

To this one can add that not only was the middle class experiencing this cultural transformation but also significant sections of the working class and particularly younger workers, in full time employment. They also had the necessary purchasing power to enter the new post-modern world of 'hyper-reality', with its confusion and distortion of historical epochs and meanings, manifest in the growth of retro-culture and consumptive existence (Harvey 1989, Boyne & Rattansi 1990). Imminent within post-modern discourse is a strong undertone of nihilism, disaster and despair, what Kermode (1988) calls 'routinised apocalypse'. This is not only borne out by the films of this time bearing similar titles and imagery but in the downturn in people's hopes and experiences. Here, social Darwinianism is generalised into *the* new moral philosophy via successive right wing governments setting new political agendas of monetarism with its rhetoric of leaning out the economy, kicking the crutches from under the indolent and workshy and revamping the welfare state (CIS 1981, 1984).

For Lyotard

> eclecticism is the degree zero of contemporary general culture: one listens to reggae, watches a western, eats McDonalds food for lunch and local cuisine for dinner, wears Paris perfume in Tokyo and "retro" clothes in Hong Kong; knowledge is a matter for TV games (1984: 76).

However, as Callinicos argues 'it all depends on who "one" is. The vast majority of the population, of even the advanced economies, are excluded from the delights of French scent and Far Eastern travel' (1989: 163).

Supporting 'post-modern' organisational theory is the notion of post-industrial society. Key to post-modern argument is information technology as organisational reorganiser

(Cooper 1989). Often these debates share the broader technologically deterministic and apocalyptic discourse of futurology (e.g. Channel 4: Visions of Heaven and Hell 1995). The growth of the 'information super highway', the increasing use of the 'Internet' for the gaining of competitive advantage (Noble 1995), and a sweeping shift towards teleworking, homeworking and the spatial mobility this offers to those connected to the 'net' is heralded by many post-modernists and futurologists alike as the beginning of a new age and new human being, indeed, as the end of the organisation and of organisational man (Handy 1995, Heydebrand 1989, Clegg 1992, Naisbet 1995).

Handy (1995), Clegg (1992), Peters (1994), Heydebrand (1989) and Naisbet (1995) offer a vision of the future in which work for many will be completely transformed. The argument is that information technology enables organisations to 'downsize' and indeed go into 'reverse thrust'. Technology is perceived as the key which will unlock the door to a new generation of high tech home workers who, through their screens, a modem and connection to the 'net', will be able to carry out all their previous work tasks and more in their own home or even whilst in transit. The emancipatory overtones of this 'information society' perspective with its class of mental workers liberated from the doldrums of organisational routine and the Taylorist rule book is compulsive whilst at the same time sinister.

The compulsion flows from the imagery of individual emancipation and self control over the pace, duration, intensity and even geographical location of ones own work activity.

Organisations like Chiat Day with their heavy reliance on teleworking and minimalist office space, absence of overt hierarchy and oppressive organs of control and accountability offer a glimpse of the possible liberation of humanity from the drudgery of paced work. The emphasis on 'social ownership of space' and equipment and lack of 'private property' in the means of production, including the lack of physical property markers like personal desks, equipment and artefacts render the impression of a quasi 'socialised' liberated work atmosphere.

On the other hand the social isolation and alienation that can occur from this shift is apparent. For example, one teleworker reported how the only buzz in his office (he worked from home) was the buzz of the hard drive on his computer[6]. Several interviewees who worked this way expressed, to me, their concern over the lack of social interaction with colleagues and how this not only adversely affected their 'sense of well being and belonging' but also how it could 'adversely impact on the creative process' as face to face 'brain storming sessions' and 'informal chats over coffee' are replaced by the splendid isolation of the isolated employee and his/her personal computer. Not only is person to person contact reduced but the new forms of contact that are established are of a more obtuse kind. Because one can tap into a variety of discourses and a truly emancipatory vocabulary, the 'net' allows creativity and free expression (Shields 1995, Jones 1994); but the morality and value judgement that peer pressure and organisational codes of conduct impose on practice and lifestyle recede.

The teleworker can, in fact, lose sense of his or her own organisational identity in proportion to the decline in the social life and body politic of the organisation itself.

More dramatic still is the professed impact of information technology and organisational 'downsizing' on individual lifestyles and broader processes of socialisation. With the disappearance of the organisation - to be replaced by a string of electrons and 'cyberspace' - lie the possibility for the disappearance of those factors serving to stabilise the daily life of organisational *man* like a job for life, with associated organisational perks - pension rights, employer contributions, and social and welfare facilities, etc. These are replaced by the insecurity of short term contracts, homeworking and self-employment.

Post-modernists see core information workers as essentially young, mobile, free and flexible (Clegg 1992, Naisbet 1995, Baudrillard 1988). The concept of a family wage recedes into history and increasingly the nuclear family with its implicit attachment to geographical space and its need and desire for stability proves unable to adapt to this new institutional setting. In this post-modern condition (Smart 1992, Tester 1993) serial monogamy, psychosis, despair and a lack of 'belonging' are argued to become the 'norm' (Robins 1993, Handy 1995). One of my interviewees, in his early thirties, voiced strong feelings on this matter:

> I have been working in computing now for several years ... if you want the glamour and prestige and money you have to be prepared to be mobile.[It's] one reason I haven't put down roots. In the past five years alone I've worked for twenty different organisations on a contracting basis, the last one paid £800 per week for three months ... Much of the work is done alone, you don't get to mix

> with other organisational members - they can resent your presence ... You feel lonely sometimes in a new company, a new town, a new country ... I've not been able to keep a steady girlfriend ... I've just drifted from one semi-permanent relationship to another ... Unless I am prepared to work full time for one of the larger institutions on lower pay and doing less innovative work this is the sacrifice I and thousands like me [have to be] prepared to make ... But I don't like it...Sometimes working from my hotel room or rented accommodation I feel totally isolated....totally alone (Consultant, Programmer/ Software Engineer).

In contrast to what is claimed to be an emancipatory life style for this key group of information workers. Handy (1995) argues one also sees the emergence of an underclass which, for whatever reason, has neither the means nor inclination to ride the information technology tidal wave. Increasingly these people are perceived by post - modernists and futurologists alike as being marginalised. They are pushed into the low wage primitive assembly end of the economy or increasingly pushed out of employment altogether through successive rounds of rationalisation and automation (Naisbet 1995, Noble 1995).

This economic marginalisation of the `under-class' (Handy 1995) is supposedly compounded by the ending of 'collective consciousness' and the rise of 'individualism' articulated in post-modern discourses which emphasise the 'ending of ideology' and politics (Foucault 1977, Keane 1988). In particular, they emphasise the ending of dominant 'meta-theoretical ideological' narratives like socialism or communism (Larrain 1994). As the masses become embroiled in a situation of 'simulacrum' (Baudrillard 1988), truth and falsity become a matter of language games. Here, 'everything becomes undecidable' (Baudrillard 1988:126) and 'libidinally charged' (Foucault 1979) in which no one discourse has any more validity or purchase on the 'truth' than any other (Foucault 1981).

In their euphoric focus on the liberating potentialities of new technology many post-modernists fail to examine the social relations surrounding the design, development and use of such technologies. Consequently, they fail to recognise that much of this technology has been concerned with tracking and tightening up accounting procedures[7]. In particular, it has been concerned with 'the efficiency in wages paid and prices extracted with, in other words, the very material world of production that informationalism supposedly replaces' (Ryan 1989: 567). I found that new technology was not only being introduced by the majority of companies in my study to improve product development, quality and costs but also, and tied into this, to increase control and surveillance of labour processes and to raise labour productivity[8]. Post-modern writers downplay the relationship between technology, capital and social change. Consequently, post-modernists are only the latest of a long line of academics infatuated with technology. Thus, when Cooper states that 'more than anything else it's technology which gives the modern organisation its special character' (1989: 2), it is as if the whole debate on the social construction of technology never happened (MacKenzie & Wajcman 1985, Pinch & Bjerker 1989, Mackay & Gillespie 1992).

Bauman's claim that 'capitalism has won the struggle for control over production' (1988: 808) or Baudrillard's (1988) claim that mass 'simulacra' has replaced class consciousness with rabid egoism is again hardly consistent with the wealth of labour process literature on worker resistance (Thompson 1995). Likewise, post-modernist borrowings from post-Fordist and flexible specialisation theory has come under heavy criticism (Mously 1987, Pollert 1988, Hyman 1988, Thompson 1991). Fordism was never the sole, or even dominant, form of work organisation in countries like Britain. Fordism and Taylorism were, as Hirst and Zeitlin (1989) acknowledge, adapted and modified as a consequence of changing local, national, regional, cultural, political and economic conditions, producing a variety of amalgams. More importantly, deskilling is not the only concern of capital. Many post-modernists share Braverman's reified view of capitals need to deskill and control (Thompson 1991). Consequently, they assume that Taylorism is *the* production logic of capitalism. It is, thus, difficult to perceive within this model further non-Taylorist transformations of the labour process. Not only is there a neglect of worker resistance in Braverman's model but so too in that of post-modernists, who downplay resistance and emphasise cultural homogeneity and harmony within organisations (Clegg 1990). Like Braverman, post-modernists also have an inadequate grasp of capitalism and, significantly, the operation of the law of value and its effect on the accumulation process. As profit rates begin to equalise in any given branch of production, capital will tend to seek either new methods of surplus extraction or to move into entirely new branches of production. This ebb and flow of capital into and out of different branches of production, in search of above average rates of profit, leads to a tendency towards the consolidation of old skills and techniques in those branches of production becoming fully capitalised and an opening up of new skills and techniques in the newer sectors of production. This should caution against the making of universal statements about deskilling or specific control strategies and, in particular, of characterising, entire historical epochs as either Fordist/Taylorist, post-Fordist or post-modernist.

The post-modern assertion that organisations are becoming more decentralised, leaner and by implication democratic represents an uncritical acceptance of much of the managerial literature emphasising 'open door' policies, anti-hierarchical managerial structures and 'harmonised' work relations. As Thompson notes:

> Essentially what we are seeing is a duality in which the decentralisation of the labour process and production decisions (through mechanisms as diverse as profit centres, subcontracting and quality circles) is combined with increased centralisation of power and control over the spatially dispersed, but interdependent units' (Thompson 1991: 8).

Baran (1988) cites numerous cases where computerised data is used to monitor workers' productivity and status and to measure labour costs against that of other plants.

My research indicates that in the current economic and political climate, extensive opportunities exist on the shop and office floor to electronically monitor and reintegrate decentralised tasks and locations:

> Our computer based Manufacturing and Resource Planning system along with our incorporation of a 'just-in-time' and total quality management programme have meant that at the same time as downsizing our organisation - for example,

> subcontracting work out, reducing middle manager and many supervisory grades, shedding labour in stores, etc. - we have at the same time, been able to tighten up control of the overall production process and the different grades of worker ... (Personnel Manager, Magnetic Tape Manufacturer, Wales).

The post-modern concern with the removal of hierarchy within organisations, such as the middle layers of an organisation is not the same as altering the basic power structure. Companies like MacDonalds or Collorol claim 'no boss' structures, yet there are elaborate hierarchies based on incentives, badges and grades (Thompson 1991). More importantly, new forms of work organisation, like quality circles and quality teams make it possible to have an ostensibly flatter organisational structure but even greater concentration and centralisation of power in managerial hands. This is particularly true when used in conjunction with new work cultures, emphasising harmony and co-operation interwoven with appropriate monitoring technology. My research reinforces the view that whilst some firms are 'leaning out' the hierarchy; they are, at the same time, increasing control over workers:

> This company likes to think it is very open and fair ... In many ways it is ... but ... it's like the film Stepford wives in here: if you are a woman ... all's happy so long as you accept what you are told and don't think too much about things ... For example, I work in a group of 15 ... There's 15 girls in this quality team [and] we make suggestions for quality improvements. We report weekly on productivity and problems experienced with particular components or processes ... we are encouraged by the bosses who are *all* men to be open and to stop production when we see a fault, etc. ... The pressure is really on you, in these groups and it's on you because your pay and bonus, as a group, is related to your productivity and performance in terms of suggestions, attitudes, stoppages, quality of batches, etc. ... and at times it's unbearable ... I can't keep up the pace all the time and other girls feel the same. We don't want to let each other down because

> we know at the end of the week the bosses will display the names of those girls whose work was below par ... They can get victimised ... I haven't been but friends of mine have ... and the victimisation is worse and hurts more because it's from girls in your own team ... so the pressure to succeed and try hard is always on you ... You don't want to let them down ... It's built into the system (Shop Steward, Japanese Domestic White Goods Manufacturer, Wales).

The Systems Manager of the same firm responded,

> Let's be frank ... nobody is claiming we've got total democracy here or anywhere else ... It's probably unworkable ... But what we do have is contented workers and a viable business ... I'm under no illusion that senior managers are running the show and are doing a damn sight tighter job of it than before ... It's really hands on here and I'm proud of it (Systems Manager, Japanese Domestic Goods Manufacturer, Wales).

Thompson (1991) argues that post-modern emphasis on decentralisation and desegregation of large companies likewise does not stand up to scrutiny. There has been an unprecedented number of mergers and acquisitions in the past few years. One of the main premises of the Cecchini Report is that central economies of scale necessary for restructuring for the single market would precisely be driven by the merger and acquisition process.

Post-bureaucratic arguments (Clegg 1990, Parker 1990, Heckscher 1994) not only wrongly interpret changes in the structure of modern organisations, they vastly overestimate the extent of the challenge to the domination of the large firm itself, arising from small firms, subcontracting, and franchises. Thompson (1991) argues that today the power of large firms is at its strongest over the smaller units, desegregated or otherwise (1991: 10). For example, it has been well documented how Japanese companies exercise hegemonic power over the satellite firms that supply them (Kumazawa & Yamanda 1988). Likewise, the increasing number of franchises belies the control that the central company imposes. Felstead (1991), for instance, documents how franchisees have to accept precise procedures, criteria and performance targets governing operations. Agreements such as those imposed by MacDonalds frequently contain clauses that stipulate contracts can unilaterally be modified by the franchiser. Ironically, as Thompson (1991) argues, given the post-modern emphasis on language, the original French meaning of franchisee - 'freedom from servitude or restraint' bears little relationship to practice.

Post-modernists stress that modern organisations are rule-bound with tight job specifications and detailed divisions of labour (Clegg 1990, Gergen 1989). Drawing on debates ushered in by Piore and Sabel (1983, 1984) and Atkinson (1985) on flexible working and the flexible firm, post-modernists assert we are witnessing a deconstruction of conventional job boundaries and definitions and a shift towards more flexible polyvalent forms of labour. The problem with this argument is that there is little empirical evidence to substantiate claims of sweeping, flexible specialisation (Pollert 1987). The notion of a paradigm shift in work organisation, implied in the flexibility thesis, ignores the fact that capital has always adopted a variety of strategies of labour control and utilisation. Notions of flexibility are, likewise, poorly theorised: flexible for who, and by what criteria? Does this flexibility imply greater exploitation? Post-modernists ignore these issues and, make generalisations about consumers who, through the exercise of their purchasing power, compel organisations to reassess their labour and machine utilisation policies. The market and consumer are thus reified and business becomes an epiphenomenon obligingly following our spiritual and cultural needs as consumers, striving to deliver to us exactly what we want: perfect consumer democracy.

Post-modernists do not understand, Thompson argues:

> that flexibility and interchangeability of functions is entirely compatible with extremely tight job and task specifications, as experience at companies as diverse as Nissan and McDonald indicates' (1991: 11).

At McDonalds, total flexibility among crew members is combined with standardised products and precise planning of subdivided tasks, underwritten by the book - a 385 page operations manual, crammed with detail, such as 'cooks must turn, never flip, hamburgers one, never two at a time ... cashiers must make eye contact and smile at every customer' (Silver 1987). Sayer makes the point that flexibility relies heavily on:

> The performance of workers who are technically unskilled or semi-skilled but behaviourally highly skilled (1986: 67).

Many employers are utilising changes in employment legislation and labour markets - particularly high unemployment - to create the desired culture of flexibility and co-operation. My research indicates that firms are spending a great deal of time and effort on recruitment and selection, with even franchisers using lengthening waiting lists to screen out 'undesirables' and to ensure 'correct' socialisation of employees. Deal and Kennedy argue:

> Strong culture companies go into the trouble of spelling out, often in copious detail, the routine behavioural rituals they expect their employees to carry out (1988: 15).

I found that management are taking advantage of high unemployment, favourable legislation and changed political circumstances to drive through new working practices and work cultures:

> Let's make no bones about it, the last ten years have seen sweeping changes in peoples' attitudes to work ... It doesn't take a genius to see that in these current conditions, the workforce will be more amenable to changes in working practices ... I have altered many job definitions and overcome many arbitrary job boundaries ... set by the unions years ago ... I expect to see willingness and flexibility in my workforce ... not rigid job demarcation ... particularly the process workers and routine workers ... We readily shift them from task to task ... (Managing Director, Chemical Company, Scotland).

Post-modernists put a lot of emphasis on culture as the glue which holds decentralised parts of the new organisation together but miss the point about the bureaucratic consequences.

> Whenever you have what appears to be a successful decentralisation, if you look more closely, you will discover that it was always preceded by a period of intense centralisation where a set of core values were hammered out and socialised into people before the people were turned loose to go their own "independent" ways. (Wiek cited Alveson, 1990: 42).

The idea of post-bureaucratic organisation that infuses post-modern organisational discourse owes more to an uncritical, unchallenging acceptance of the global prophecies of pop management than to a critical exploration of organisational changes:

> The "break with bureaucracy" fits nicely into an era when entrepreneurial activities are a highly valued part of the cultural and political climate. (Thompson 1991: 13).

Post-Fordism

A Foreword

A variety of theorists have utilised the term 'post-Fordism', in their attempts to analyse changes taking place in manufacture and society. Key contributors to the British debate have been the neo-Gramcian Marxists, grouped around the political magazine Marxism Today, which argues that we are living in 'New Times' which represent a decisive break with the economic and social trends of much of this century (Jaques & Hall 1989). Lash and Urry (1987) claim that organised capitalism has been replaced by a new phase and by new forms of institutionalisation: 'disorganised capitalism'.

'Post-Fordism' draws heavily on a vision owing much to Gramsci's essay 'Americanism and Fordism' (Gramsci 1971) and Braverman's 'Labour and Monopoly Capital' (1974) in which Taylorism is presented as a form of production and labour organisation characteristic of the Fordist era. Fordism is referred to as a system of mass production utilising assembly line technology, special purpose machinery, detailed division of labour, based on increasing task fragmentation, the production of standardised goods, 'technological efficiencies' of planned production, economies of scale and the development of a mass market coupled to appropriate macro-economic policies, i.e. Keynesianism. The Fordist system, according to Post-Fordists, implies a definite type of society: industrial society based on a predominantly male, full time, working class concentrated in large plants in large industrial cities. According to theorists of this model the assembly line economy promoted industrial unionism and workers parties in politics with its concentration of labour in large plants, performing essentially routine work, in a full employment economy. In short, social democracy was underwritten by Fordism and the Welfare State.

Post-Fordists homogenise the post-war world so as to be able to stress the social and political differences after 1973. This roughly corresponds to the time of the oil crisis which is the point recognised by post-Fordists as marking the beginning of the end of

Fordism. Not only are regional complexities obliterated but there is no real explanatory core to the post-Fordist case other than the decomposition of Fordist structures (Hirst & Zeiltlin 1991). The post-Fordist case involves, by and large, borrowing and radically simplifying the flexible specialisation approach to manufacturing. Hall (1989), Robins (1989) and Leadbeater (1989) assume that new 'flexible' production techniques, work methods and organisational cultures have swept across the manufacturing spectrum. From this, they read off equally dramatic changes in society, utilising a diluted post-modern discourse. Hence, Marxism Today's assertion of 'New Times' as a fluid, transient society dominated by shifts from collectivism to individualism, from production towards consumption and from substance towards style (Marxism Today, December 1989).

Post-Fordism in the hands of Marxism Today is essentially pop-sociology, an undertheorised but, nonetheless, entertaining imagery. In the hands of Jessop and some of the leading Regulationists (Aglietta 1979, Lipietz 1988, Mjoset 1985) who draw upon some of the concepts of post-Fordism it becomes a serious theoretical tool. It is both to do justice to this more elaborate articulation of post-Fordism and to evaluate critically the work of the Regulationists that I have chosen to combine discussion of the two schools in the following section.

Regulation Theory and Post-Fordism

Regulation Theory sets itself a large task: to theorise a particular accumulation regime and its regulative ensemble. In attempting to do so it offers a rich and, at times, persuasive interpretation of change.

Regulation Theory (RT) in Britain has been primarily associated with the debates surrounding Fordism and post-Fordism. However, Fordism and post-Fordism are simply Modes of Regulation (MOR), concepts which RT can either draw on or ignore. However, the degeneration of RT into post-Fordism has arisen through too close an identification with the 'new realism' which came to prominence amongst sections of the 'left' in the 1980s (Sayer 1990, Clarke 1988). RT, however, is not some monolithic bloc, but encompasses many schools of which the Marxism Today version is only one[9]. RT is in part a reply to orthodox 'equilibrium' economics, although it can be identified more generally as 'political economy'. Regulationists attempt to take up where Marx left off in analysing the laws of motion of capitalism and capitalism's internal development. In particular, they are looking for ways in which capitalism attempts to overcome its contradictions as manifest in the tendency of the rate of profit to fall. As Bonefeld argues, RT is:

> Concerned with understanding how the reproduction of the capital-labour relation is historically realised and regulated and how capitalism is prevented from collapsing (1987: 96-127).

Jessop attempts to extend RT beyond political economy into an analysis of the 'superstructure' in order to understand how capitalism achieves its regulative capacity:

> Answers [are to be found] ... in specific institutional forms social norms and patterns of strategic conduct that both expressed and regulated these conflicts (1988; 14).

Thus, rather than predicting the 'final stage of capitalism' or awaiting its 'imminent collapse', Regulationists seek out its regenerative capacity to transform itself. What is new about the Regulation approach, however, is the 'teleologism' built into their analysis. Thus, for British Regulationists, the present crisis has within it the seeds of a new system, namely, post-Fordism[10].

In Britain, at least, RT seeks to explain new emerging social and political relations based on post-Fordist productive relations:

> Post-Fordism is the nearest thing we have to a paradigm that can link widespread changes in forms of production to changes in class relations, state forms and individual identities (Rustin, 1988: 36).

Taking account of Marxist debates over relative autonomy that have occurred over the last twenty years, RT seems to be coming home to its material roots, encompassing notions of class struggle, changes in production, consumption and the state. Probably the chief achievement of RT is this shedding of dogmatism and for bringing back the debate from degenerating into liberalism or idealism. For Discourse Theory everything, including the economy, is discursively constructed (Keane 1988, Baudrillard 1988, Lyotard 1987, Foucault 1977) whereas Regulationists argue that they accord the economy a rightful place.

> The economy plays a determining role, but the political has the dominant role (Jessop 1989: 12).

Jessop argues that Regulationists do not privilege any one point over any other but acknowledge different levels. The 'correspondence' between these levels is not automatic but the product of struggles[11]. The figure below represents one possible regime of accumulation and its corresponding regulative ensemble.

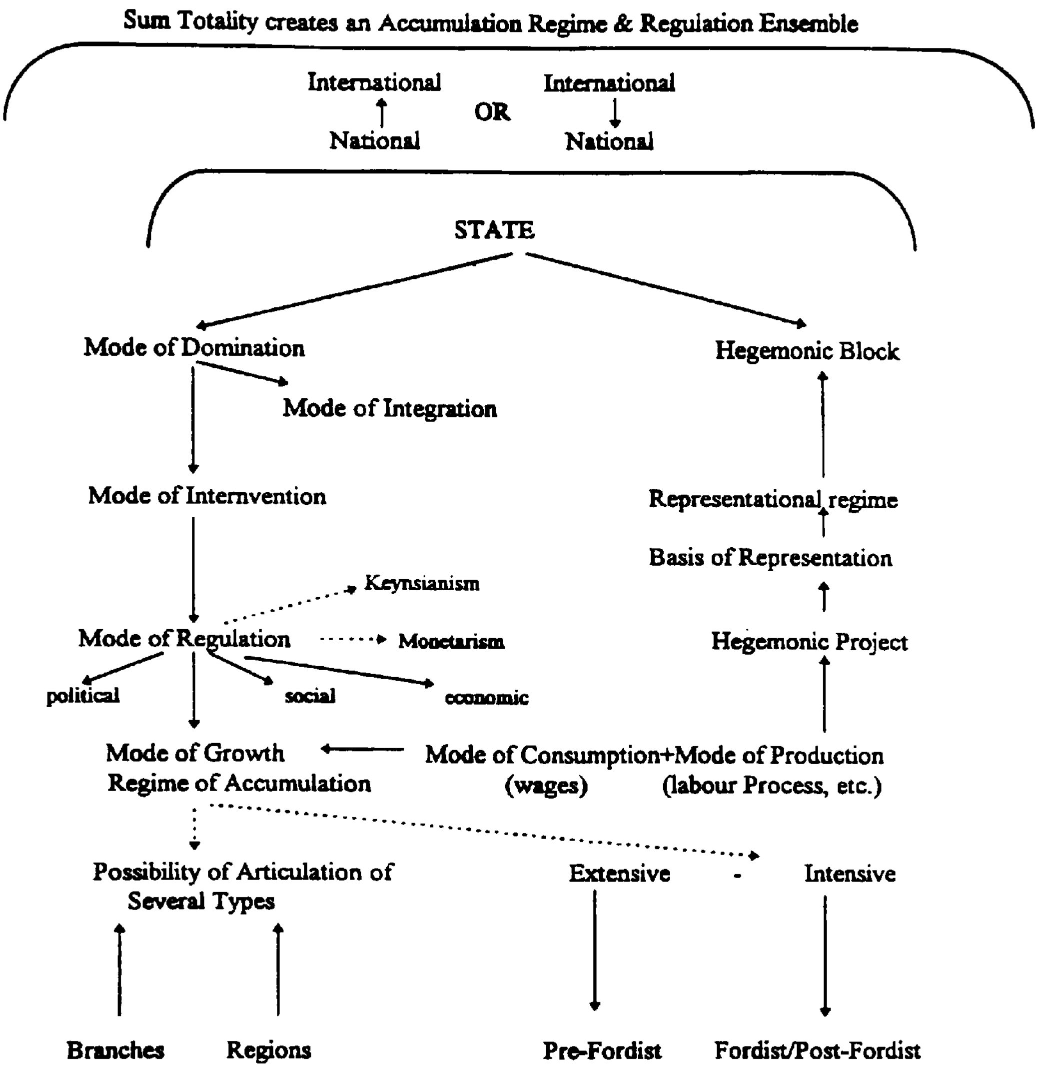


Figure 2. Accumulation Regime and Regulative Ensemble.

Jessop is keen to emphasise the dynamism of RT. No Mode of Regulation can last forever, new regimes arise, but this is not determined in advance but contingent upon struggle. With RT, transitions are not seen as inevitable, nor are they deemed to be automatically successful. 'Flawed' regimes *can* come into existence (hence Jessop's theory of "flawed Fordism" in Britain).

The Transition to Fordism

Aglietta (1979, 1982) sees two main Modes of Accumulation (MOA), Extensive and Intensive. More popularly referred to as pre-Fordist and Fordist/post-Fordist modes of growth. This opens up ambiguities in the Regulation approach as some Regulationists talk of post-Fordist regimes as *new* modes of accumulation whereas Aglietta, saw both Fordist and post-Fordist accumulation regimes as part of the Intensive Mode of Accumulation.

For Aglietta, the extensive period of growth was marked by the spread of industry rather than maximisation of resources and labour. Under the system of extensive accumulation, Regulationists argue that non-commodity relations predominate over commodity relations. Within the intensive regime commodity relations come to predominate and capital perfects its technique of labour control along Fordist lines.

Regulationists argue that the 1929 crisis reflected the disjuncture between productive capacity and consumptive capacity a disjuncture which they maintained existed until the

1950s when production and consumption capacities were harmonised on the basis of a Fordist ensemble (Aglietta 1979, Lipietz1986).

This ensemble is then analysed at several levels the productive level, the labour process, consumption patterns and the superstructure supporting the Fordist Regime of Accumulation (Jessop 1988).

The Productive Level - Fordism is based on mass production and mass consumption. Products are standardised and a new balance is said to be struck between Department 1 & 2[12].

The Labour Process - Mass production is achieved by a mechanised assembly line based on Taylorist (time and motion) methods. The task is deskilled to the level at which it can be performed by a 'trained gorilla'.

The argument is that these two processes revolutionised production to the extent that other firms were compelled to adopt the same techniques on pain of extinction and thus Fordism becomes the dominant, or generalised 'mode of production' for Regulationists.

Consumption Patterns - Consumption is massified and demand maintained by a variety of means, in which hire purchase and credit play important roles. Trade Unions also grow and create bargaining structures so as to match wages to profits and/or output and so maintain demand. The Keynesian welfare state ensures the absence of possible slumps and welfare benefits ensure the consumption capacity of the poorer sections of society.

The Fordist Superstructure - Some elements of this have already been noted, i.e. Keynesianism, the Welfare State and collective bargaining. Many Regulationists see a close fit between the Regime of Accumulation (ROA) and the socio-political system (Hirsch 1983). A sophisticated abstract economism thus breaks through. The Mode of Integration (MOI) of the working class is said to switch from the repressive to the ideological. Poulantza's (1978) notion of the increasing penetration of the state into more and more spheres of society is particularly relevant here. Political parties become transformed as notions of class are said to wither, replaced, instead, by status groups, consensus politics, and a one nation strategy. The State is argued to increase its support for the economy through tariffs, active restructuring and socialising losses.

The Fordist Economy

Regulationists stress that the new mode of growth modifies the laws of capitalism in a number of spheres including the boom-slump cycle, wage relations, credit and inflation. Post-war Fordist capitalism is perceived as an entirely different regime to that of the pre-war extensive regime. Regulationists see the extensive regime as being characterised by competition and price reduction sales drives whereas under the intensive regime, competition is replaced by monopoly, stagnant wages with real rising wages, and sales increased not so much by lowering prices but by raising wages (Aglietta 1979). Inflation and enhanced credit facilities take on new force within the Fordist economy. Monopolistic capital enables firms to anticipate market saturation and depreciation which comes to be accommodated through:

1) Building it into the price
2) Building in planned obsolescence
3) Offsetting depreciation costs through:
    (a)Rising prices
    (b)Rising wages

For RT new crises emerge because powerful unions are capable of forcing up wages faster than profits. The Fordist mode of growth, however, does not collapse but rather it drifts to overaccumulation and rising 'social overheads' act as a drain on the system. Hence, Regulationists see Thatcherism as an attempt to commodify previously social costs through the privatisation of public services. As long as relative surplus-value continued to increase through productivity increasing faster than wages and increases in 'social overheads' Fordism could endure, but by the mid-seventies, Regulationists argue that this was no longer the case. The only way out was the transition to a new regime of accumulation[13].

For Regulationists, Capitalism is thus metamorphosing into a new post-Fordist mode of growth which contains the possibilities of sustained accumulation.

Post-Fordism as an Ideal Type

Regulationists define post-Fordism in terms of an 'ideal type' (Jessop, 1988) which has a number of key elements:

Product: Regulationists argue that post-Fordist manufacture is geared towards customisation and market niching. Economies of scope are said to replace economies of scale. The emphasis in consumption shifts from keeping up with the Jones's to asserting ones own individual style.

Dictatorship of Individualism: Regulationists assert the predominance of consumer choice/changed consumer lifestyles which, presumably, are fed back to manufacturers who dutifully produce the requisite commodities. Fordist methods fail to address the needs of the new discerning customer. Consequently, purpose built machines designed to build one or two items are said to be giving way to more sophisticated general purpose machines that can perform a multiplicity of tasks and produce a variety of different products.

Labour: Regulationists see changes in productive technique making themselves felt on working practices. The emphasis is said to be away from mindless repetitive deskilled work towards flexibility of labour, presumably to match the flexibility of the machines, rather than the exploitative requirements of capital, i.e. its social relations of surplus extraction. The post-Fordist worker is said to be given more tasks, particularly in quality control, which in turn has ramifications on the management structure. Whereas Fordist workers were carefully policed by layers of foremen and managers, now the need is for self-regulation along supposedly Japanese lines which typically have six or seven layers of management, in contrast to Ford's and General Motors twenty seven layers. Core trusted workers are able to secure good wages in return for 'flexibility' and co-operation with management (as in the 'New Unionism' of the EETPU, etc.) and at the expense of the peripheral work force, on low pay, no benefits and short term contracts. These workers, along with the long term unemployed, are argued to constitute a new 'underclass' excluded from the affluence of the majority, within the post-Fordist economy, and left to survive on the fringes of that economy subject to policing, intimidation and further marginalisation by a minimalist State professing a hands off free-market philosophy (Leadbeater 1987).

The Superstructure: Regulationists associated with the Communist Party of Great Britain and 'Marxism Today' see the Trade Unions giving in to a 'new realism' or 'new unionism' as the sting is taken out of unions via incorporation into the new post-Fordist consensus, with core workers and their unions offering co-operation with employers in return for benefits. The result is the growth of 'company unionism' and the break-down of traditional bargaining and negotiation procedures. Under post-Fordism, political parties are also said to become more like 'Public Relations' agencies, regulating between the elements of a segmented, divided society. Presidential populist styles come to predominate as personalities replace real issues. Consensual democracy of the Fordist era is argued to give way to 'plebiscitary populism' and a 'security state' to discipline the underclass which rapidly learns it has nothing to loose but its chains.

The concepts, 'regime of accumulation' and 'mode of regulation', are attempts to revise and broaden the scope of hitherto economistic Marxism's, to take account of the role of the broader social system in the maintenance and reproduction of capitalism. As Rustin argues:

> The originality of the regulation approach is its recognition of the systemic consequences of changing technologies, forms of organisation and class relations, both in the economic sphere itself (production, circulation and consumption), and for neighbouring spheres of political and social life. The disagregation of essentially dualistic forms of class relations, institutionalised in forms of industrial relations and government in the period from the New Deal to the inflationary crisis of the 1970s, into a more dispersed, differentiated, and individualised series of relations between capitals and its various social partners and antagonists, does seem like a major shift in the axes of social organisation. It also seems that the development of information technologies and the immensely powerful and cheap communication which these give rise is the essential motor of these changes, without which they would not have been able to occur (1990: 42).

Regulationists and post-Fordists offer a tempting theorisation of change within the capitalist mode of production. Certain features which they identify such as moves towards flexible production processes or the individualisation of consumption, have become part and parcel of the advertising, media and academic debate the accepted 'common-sense' discourse of the 1990s.

Regulation theory is emerging out of a more orthodox Marxist school but in the process much is being lost and revised. In particular, value analysis, the very linchpin of Marx's own assessment of the developmental tendencies of capitalism, is downplayed and misunderstood. As Gough argues:

> Current debate on 'post-Fordism' is centred on technical-organisational questions. The forms of the labour process, organisation of the firm, inter-firm relations and the relation between production and consumption are approached from this view point, the viewpoint of industrial sociology, managerial and organisational theory. What is neglected in the debate, is how the technical-organisational questions fit with the social relations represented in value. This is not a small omission. Value is the key social representation of labour in capitalist society. The question of value is the question of how different labours are commensurated; of the means by which surplus labour is extracted from workers by capital (surplus-value); of the dynamic of capital accumulation (self-expanding value, the circuits of capital through money to productive forms to money): the question of money, credit and capitalisation; and of the contradictions within these forms. The current discussion of 'post-Fordism' abstracts from these questions of value analysis and ignores the contradictions of the capitalist mode of production which value analysis has demonstrated (1990: 1-2).

Gough's argument is that 'post-Fordist' capital labour relations can be theorised more coherently through value analysis and that this analysis suggests that present organisational-technical forms, i.e. 'post-Fordism' are *episodic*, a function of the period of crisis, rather than the features of a new long term regime of accumulation.

Given that Aglietta's text 'A theory of Capitalist Regulation' was concerned precisely to relate the labour process and forms of organisation to value production, current Regulationist writing downplays value analysis. Geddes draws out the determinism of such an approach:

> Post-Fordist theory proposes that at the heart of the new era of post-Fordism, are new forms of capital labour relations. These forms are typically assumed to be able to overcome the problems for capital contained within the Fordist labour process, and thus constitute the basis for a qualitatively new era of accumulation. Implicit in this assumption is the notion that such forms are relatively stable and productive - otherwise they would not be able to constitute the basis for a 'sustained long wave of accumulation (1988: 93).

The post-Fordist model assumes stabilisation of class relations: bought out 'core' workers complying with management, i.e. utilising their initiative within a variable labour process, and 'peripheral' workers controlled within the labour process and within negotiations over wages and conditions out of fear of the sack. They are also easily replaced by the reserve army of unemployed.

However. Elam and Bjorsen (1989) and Gertler (1989) have pointed to the weaknesses of 'flexible integration' as a strategy of accumulation, i.e. the high degree of dependency of firms on skilled, multiflexible labour and lack of 'tautness' characteristic of 'just-in-time' production systems. Of course, Regulationists may agree that these new systems are unstable and argue that this does not undermine the approach of the Regulationists in any way. But, surely, the very indeterminacy of such relations bring into question the viability of constructing models emphasising emerging 'regimes of accumulation' which have, as their underlying assumption, the generation of historically superior or stable 'flexible integration' accumulation forms. As Gough (1990) argues, the class relations of the 'core' have specific contradictions, largely by-passed by the Regulationists. To the extent that, in the interests of collaboration, security of employment is guaranteed by capital and labour can use this security to resist intensification. The high organic composition characteristic of the core gives labour the power to immobilise expensive plant. High wage differentials between core and peripheral workers may help in establishing control but to the extent that they do not correspond to productivity differences, they disrupt the role of value in establishing proportionality's across the division of labour. Within each firm, the high integration of tasks and stages of production makes it difficult to apportion rewards according to output or effort. This produces a tendency to hourly or uniform payment rather than output related payment. Yet this conflicts with the individualisation of terms of employment and incentives to individual initiative which are said to characterise post-Fordist relations within the 'core'. This is possibly one reason why Japanese firms have sophisticated measures of punishment underlying their more paternalistic face (Briggs 1986, Williams *et al* 1990). The problems do not stop here, however, because in the periphery insecurity of employment produces low commitment from workers and low investment in training from employers. These tend to limit the volume of production per worker and especially the quality of production. Thus, in both core and periphery, capital faces problems of simultaneously obtaining co-operation from workers and imposing control (Friedman 1986).

Regulationists theorise the transition to post-Fordism as a 'technical organisational' question. The crisis in the old regime of accumulation is articulated as the crisis of Fordist production or organisational techniques, not as an accumulation crisis. This has dramatic repercussions on the theorisation of capital-labour relations. A period of crisis tends to lead to increasing differentials in wages and conditions via the differentiated ability of firms to pay and the expression of competitive pressures in incentives. The ebb and flow of capital in and out of sectors (in an attempt to generate above average rates of profit) and the equalisation of profit rates within sectors (and also the resultant fall off and renewed search for new sources of profitability) lead to combined and uneven development of sectors, productive forces and relations of production. This results in capital - labour differentials which are further exacerbated by the increased level of unemployment. These mechanisms, arising from the value relations of capitalism, are sufficient in themselves to explain not so much a core-periphery but a long spectrum of wages and conditions and emphasise the instability of particular groups of workers on this continuum.

Stagnant and uneven accumulation tends to have a disciplining effect on all workers. But for skilled workers there is a contrary tendency. In periods of low average profitability or uncertainty about future profitability, investment in the reproduction of skilled labour power tends to tail off leading to an increase in the bargaining power of this group. This divergence of bargaining power between different groups of workers can appear as core-periphery differences. Further, a period of crisis is a contradictory time in which to introduce highly integrated and/or high organic composition labour processes. Whilst the disciplining effect of the crisis can facilitate the introduction of such processes, the co-operation of the workforce necessary for the successful utilisation of such processes is constantly undermined by high unemployment, calls for wage restraint, wage cuts and widening or accentuated differentials.

In a period of crisis, the contradiction between the spatial mobility and immobility of capital becomes sharpened but not resolved. As Harvey (1982) argues, the social nature of capitalist production tends to produce spatial concentration of production due to socialisation of labour and skills in particular industries and regions, the mutual dependency of different branches of production, the requirement for supporting infrastructures, local skills and knowledge and the long turnover times necessitated by many types of fixed capital. In times of crisis this 'immobilisation' of capital has its contradictions, which, manifest in value terms, are none other than inflation in ground rents (land values), in the price of infrastructure and in the price of labour power (Harvey 1982). The immobility of capital tending to prevent an adequate commensuration of labour in different localities, regions and countries and consequently from adequately rendering labour as abstract labour and labourers as abstract labourers. Thus, there is also a tendency towards spatial mobility as capital seeks to remove the particular concrete ties that labour has to it. This leads to the reproduction of core-periphery in geographical form, although this is a highly unstable division, as capital is able to decentralise from the core or recentralise from the periphery. In contrast, post-Fordists tend to see the 'peripheralisation' of capital as evidence of a dramatic historical rupture in regimes of accumulation rather than as a derivative of the contradictory nature of the capitalist accumulation process.

Regulation theorists tend to see the rapid technological innovation of post-Fordism, i.e. 'flexible integration' as overcoming the root of crisis whereas this technological dynamism (in value terms a reflection of the rise in the social organic composition of capital) is the very precursor of crisis. Moreover, the particular dispersion of wage increases and differentials has further narrowed the range of potential consumers throughout the 1980s. Regulationists might argue that the relation of wages, productivity and prices obtaining over the last ten to fifteen years is episodic and a function of crisis, and that a new regime of accumulation which accomplished a generalised revival of the international capitalist economy would involve a different wage-productivity-price relation. According to Gough (1990), such an argument concedes a lot since it implies that the supposed new regime of accumulation cannot be read off from current trends, and that the wage relation in the 1970s and 1980s has been constructed by a crisis of accumulation, rather than by 'post-Fordist' changes in the labour process.

A further feature identified within the post-Fordist literature is the supposed match between product variety demanded by consumers and the product variety possible with the dominant labour-process. Standardised Fordist production runs are supposed to give way to shorter more varied 'niche', even customised products. Several points need emphasising here: first, there is no reason to suppose that new labour processes are being used to create greater product variety than classical Fordist or Sloanist labour processes (Gough 1990). Second, such an argument ignores the fact that production under capitalism is first and foremost production of exchange-value (although every exchange value must have a use value). Individual capitalists do not care what they produce so long as they produce an adequate rate of profit. The supposed tendency towards variety in products may thus be a function of the value relations of a particular conjuncture, the impact of the crisis of accumulation on the structure of consumer demand, increasing differentials and cheapening of the elements of Department 2 rather than the subordination of capitalist production to consumer interest. Finally, value analysis indicates that variety is episodic, a function of this period of crisis rather than an indicator of a new more permanent regime of accumulation (Hyman 1988, Thompson 1991, Williams and Cutler *et al* 1987).

One can challenge the notion of a Fordist regime of accumulation both theoretically and empirically. My research confirms that within capitalism there are a variety of labour processes. One need not be prioritised over the other, as the key element is production of surplus-value. Historically this has tended to take the form of the subsumption of labour to capital in the machine process, i.e. the extraction of relative, as opposed to absolute surplus-value, but the two are not necessarily mutually exclusive but contingent, amongst other things, on class struggle[14].

Regulationists argue that it was a Fordist accumulation regime which was responsible for the long-wave post second World War boom, but as Clarke (1988) and Mandel (1975) have argued, the post-war reconstruction was not marked by Fordism per se but by austerity, sharp industrial and political class struggles and by increasing state intervention and credit expansion. The driving force of accumulation in this period was not mass consumption and Keynesianism but profits. The dynamism of the boom derived from the high profits of the immediate post war era, pent up demand, and the massive increase in the product of manufacturing industry absorbed by the non-productive sectors - notably the State-military, infrastructure, etc.. The post-war boom was certainly different from previous booms. But the qualitative difference lay, not in the structure of the regime of accumulation, based on Fordist labour processes, but in the fact that national and international authorities were willing to sustain accumulation via an unprecedented expansion of the credit system. This prompts Clarke to conclude:

> The regulation approach not only over-estimates the stability and duration of 'Fordist' modes of regulation, it also overestimates the contribution of Fordism to the post war boom (1988: 16).

Aglietta was aware that the Fordist accumulation regime was marked with contradiction this took the form of inflation through monopoly price fixing, used to counter rising wages, social overheads and depreciation, which were manifest in a tendency for the rate of profit to fall. For Aglietta, new crisis could only be overcome and accumulation sustained if capital could find ways of increasing the production of relative surplus-value.

The problem is that new 'flexible' modes of increasing relative surplus value are abstracted not only from class struggle but the market and the international division of capital and labour. The fact is that some companies may introduce flexible production processes only to find they do not have the skilled labour or industrial relations to operate them successfully. Additionally, they may find that the market for such products changes and that it is necessary to switch to dedicated high volume production. There is also the possibility that competition will force investment in dedicated products or that monopoly position dictates a squeezing out of 'flexible' competitors through utilising high flows and price rigging, etc.

The weaknesses of the Regulation approach flow from their theory of overaccumulation. Aglietta (1979) ascribes overaccumulation to the surplus profits derived from Department 1 which are argued to arise as the result of invention of new machines or as a result of increased demand resulting from the growth in the social organic composition of capital. These surplus profits are argued to fuel the 'animal spirits' of capitalists in Department 1, their resultant 'euphoria' sustaining their over-investment even when over-production occurs. Thus, for Aglietta, the source of overaccumulation is the prospect of surplus profits provided by the exploitation of temporary market opportunities, and the explanation is Keynesian, overaccumulation deriving from the subjective irrationality of entrepreneurial expectations.

However, Aglietta misses the point: Marx sought to locate the contradictions of capitalism, not in the subjective irrationality of capitalists but in the objective features of the capitalist mode of production. Aglietta's critique of neo-classical conceptions of the market does not go far enough: he explores the relations between the major Departments of production without questioning the efficacy of the market in regulating relations within branches of production, thus abstracting from the uneven development of the forces of production within specific branches of production which is the driving force of accumulation, the source of overaccumulation and crisis. As Clarke argues:

> It is not surplus profits offered by a growing market but competitive pressure, based on the uneven development of the forces of production, which forces individual capitalists to seek to constantly revolutionise the forces of production (1988: 19).

The tendency towards overaccumulation in all branches of production, however, new, old, big or small, is not determined by the anarchy of the market, but by the contradictory form of capitalist accumulation. As competition compels capital to constantly revolutionise and expand the forces of production, without regard to the limits of the market, the consequence is that new methods of production become generalised through devaluation, liquidation, intensification of labour and redundancy: the developmental norm of capitalism.

Keynesians and Regulationists see overaccumulation and underconsumption as two sides of the same coin. Both have a distorted understanding of the relationship between credit and overaccumulation. In the boom, credit expansion enables capital to temporarily suspend the barriers to accumulation by enabling production to take place in those sectors operating with below average rates of labour productivity, in short those producing with more than the socially necessary labour needed to produce. This is fine whilst credit fuels expansion of market and finances new ventures and consumption but it does not solve the fundamental problem, namely, the need to restructure or rationalise the various branches of production. By 'socialising' the costs of the devaluation of capital, credit merely stimulates the inflationary overaccumulation of capital with the attendant risk of even more devastating crises in the future as the reality gap between prices and actual values widens.

Regulationists argue that the historical tendency towards overaccumulation is mediated by institutional forms. However, these institutional forms are not the 'modes of regulation' and 'regimes of accumulation' which Regulationists document. Rather, they are the institutional forms of class struggle. The overaccumulation of capital takes on the form of an intensification of the competitive struggle between capitals and of the industrial struggle between capitalists and workers.

These struggles are conditioned upon a historically developed institutional form of labour relations, industrial structure, geography, credit, system, etc. The struggle is not confined within these forms but is a struggle to maintain or transform them as capitalists and workers confront these forms as barriers to their own reproduction. Overaccumulation crises do not automatically lead to the dislocation of the structural integration of the regime of accumulation. They lead to an intensification of the competitive and class struggle which impose themselves on the State which cannot simply be reduced to a superstructural expression of structural forms of the monetary and wage relation as Regulationists imply. This is because the State plays a fundamental role in attempting to confine social reproduction within the alienated forms of the wage and monetary relation by enforcing the laws of capitalist property and contract and by regulating the reproduction of the working class, through systems of social administration. One reason why the institutional forms of capitalist social relations are not 'modes of regulation' which institutionalise some kind of social democratic class compromise, according to the structural imperatives of a regime of accumulation, but rather institutional forms of class domination which express a particular configuration of class struggle.

For Regulationists, the relative stability of a particular accumulation regime has to be assured by corresponding modes of societal and hegemonic forms of integration/repression: the 'mode of regulation'. The concepts of integration/repression impinge, mainly at the level of the state. Poulantzas' notion of state politicisation of more and more spheres of social and economic life is very important here. Hirch (1983) and Lipietz (1987) attempt to theorise state forms and functions in relation to changes in production, thus seeking to unite complex economic, political and ideological phenomena into a unified structure, the development of which is said to be conditioned by the laws of capitalist development and class struggle (Hirsh 1983). A particular articulation or ensemble of regulative forms is argued to correspond to a particular regime of accumulation. However, the mechanisms and processes whereby these forms come to constitute the 'regulative ensemble' are unclear. Following Gramsci, there is a strong tendency within the Regulation approach to disarticulation of the constituent elements of the regulative ensemble. We are offered concepts of 'contending historical blocs' and 'projects' but no sense of determinacy between them. No answer is offered as to which agency co-ordinates the strategy of accumulation and which one assembles the hegemonic project in order to achieve 'the state'. Consequently, the state comes out of all this more as an arena of struggle than as a class state executing the general interests of capital. In effect, and unintentionally, Regulationists thus offer a theoretical model which can underpin the very reformist conceptions of the state which many wished to challenge (Aglietta 1979, Jessop 1988).

According to Bonefeld (1987) the Regulationists dual perspective of structural determination and class position fails to recognise 'objective laws' as derivatives of the class relation. For Regulationists, it is the development of capital accumulation which determines the environment of struggle. Class struggle thus loses Marxist significance as the motor force of history and we are left with what Bonefeld calls 'process without subject'.

Jessop (1988) denies this, arguing that Regulationists do not reduce class to a secondary factor. For example, their concept 'flawed Fordism' is taken as indicative that definitive prognosis of the transition towards post-Fordism is not possible precisely because of the unpredictability of class struggle. The 'contingent' outcome of a dialectic of structure and strategy'. However, this argument is weak. The fact that 'post-Fordism' is already theorised as an accumulation regime, in advance of class struggle, indicates the teleologism within the Regulation approach. Likewise, the Regulationist/ Poulantzian assumption of the 'a priori' *statification* of society is implicitly functional and reductionist. The state is seen to constitute, regulate, integrate and secure capitalist reproduction. Within this paradigm there is an over-emphasis on the state as the primary force of 'recomposition' of society. Regulationists exaggerate the power of the state by assuming the functionality of compatible state action toward the pre-supposed needs of capital reproduction. As Bonefeld argues:

> The stratification of society results in the Gorzian "farewell to the working class" and the welcome to its successor: social movements (see Hirsch 1980; Hirsch/Roth, 1986) ... Instead of being seen in terms of a pluralist struggle for shares in power, in order to secure the viability of a certain fractional accumulation strategy, the State should be analysed as a mediation of the historical transformation of the direct production process (Negri 1977) ... The State has once more, to be seen as at the centre of the dialectic of the organisational repressive aspect of the presence of labour within capital (1987: 123).

The consensual-concessional mode of integration which Regulationist argue constitute the Fordist period is now replaced by a hegemonic project, based on social division and marginalisation. The shift to the 'right' in the leading imperialist countries is postulated as a period of 'radicalisation' which is necessary for the restructuring of production relations on a post-Fordist basis. However, the conception of a post-Fordist historical block abstracts social phenomena from the complex diversity and heterogeneity of a transition period. As expressions of struggle, Fordism and post-Fordism are conceptualised as pure blocks, as 'accumulation regimes'. In reality, they are full of cracks, fissures and contradictions and never just a synchronisation of functionally required regulative forms. As Bonefeld argues:

> The Fordist/post-Fordist debate interprets historical tendency in terms of its more or less close approximation to a model, whose pure form is allegedly progressively disclosed. But this is to depart from the conception of historically specific determination on which Marx's own method turns (1987: 126).

Although an increasing number of commentators suggest that capitalist industry and society is undergoing qualitative change as evidenced in the plethora of terminology used to denote it, i.e. 'neo-Fordism', 'post-Fordism', 'post-Modernism', 'Nextism', 'Benettonism', 'Proudhonism', 'Japanisation', 'Flexible specialisation' etc.. There is little certainty as to its future character. Faced with such complex and contradictory social phenomenon it is tempting to go for 'binary histories': industrial versus post-industrial, Fordist versus post-Fordist, modern versus post-modern, etc.. Such a process, as Sayer argues, is fraught with risk and misconceptions:

> Inevitably we end up with overburdened dualism's and overelastic concepts. Worse, we invite a consequent diminution in the richness and therefore the power of our conceptual equipment. The trouble with concepts like Fordism, post-Fordism and flexible specialisation is that they are overly flexible and insufficiently specialised (1990: 17).

Aglietta's pioneering work was based exclusively on an assessment of the United States and neither the Parisian, German or British schools have took an internationalist perspective of production and consumption under capitalism. The international market, international division of labour, combined and uneven development of capital, and imperialist articulation of the world economy have tended to be pushed into the background, as each school has sought to examine those particular regulative tendencies of interest to it. These tendencies are invariably national, and invariably geared towards leading edge sectors to highlight those processes facilitating a new accumulation regime and mode of regulation. The abstraction of regimes of accumulation from the international division of labour and multinationals ability to exploit the vagaries offered by differently constituted social formations casts doubt on the theoretical and empirical validity of the model.

The lifelessness of the Regulation approach becomes all the more stark when one contrasts the internationalisation and interpenetration of capital in different countries. The search for profits may dictate, within a given social formation (comprising given labour skills, geography, political climate, resources, etc.) that mass production on 'Fordist' lines are introduced, for example, car body panels made in Korea and Spain whilst more sophisticated manufacturing processes, say, engine build, is undertaken in Belgium or Britain supplying not only more skilled labour, but a developed infrastructure which can accommodate a different number of build processes ranging from mass flow line to dedicated batch, etc. There is little theorisation within the Regulation approach of the international division of labour or capitals ability to move in and out of markets and sectors in search of average, or above average, rates of profit and the concomitant effect this has upon the composition and recomposition of labour and forms and variety of labour which may exist side by side within the same manufacturing process, or within different processes. One need not historically supersede or exclude the other because the limits to surplus-value are not merely contingent on technical or organisational divisions of labour. More importantly than this, within the Regulation approach, there is no conception of Imperialism, of Imperialist exploitation, and of the decisive skew imperialism adds to the formation and consolidation of labour processes within particular social formations.

Generalisations about 'Fordism' are spurious enough, never mind 'post-Fordism'. Thus, Littler (1985) argues that in Britain less than 700,000, out of a total workforce of 20 million, work directly on Fordist lines. Even then, few of the problems which are alleged to dog Fordism (i.e. line balancing, labour resistance) apply in these sections alone (Meegan 1988). Regulationists make too simple a deduction, arguing,

1) post-war capitalism can be characterised as Fordist
2) capitalism is currently in crisis
3) therefore, Fordism is in crisis.

It does not necessarily follow that Fordism is the cause of capitalism's crisis. Many mass production sectors are highly profitable. My own research indicates that some firms are actually switching away from 'flexible production' of 'niche' products to standardised dedicated high volume mass production. Likewise, there is no reason why new mass production sectors which do not compete with old ones should not flourish, using Fordist, or even pre-Fordist, methods so long as they are able to attain average or above average rates of profit.

Furthermore, there is no conclusive evidence to show a relative decline in rates of output or productivity increases in the mass production industries (Meegan 1988, Williams 1987)[15]. As Pollert (1987) argues, many users of the term 'flexibility' have either deliberately or unintentionally overlooked the double edged, value-laden character of the word. Flexibility in the abstract sounds agreeable but not always when considered in the concrete, e.g. the debilitating effects of working alternate blocks of day and night shifts.

> Flexibility is no more the secret of capital accumulation than is deskilling. Capitalist industry has always combined flexibility's and inflexibility's, and what are possibly emerging now are new permutations of each, rather than a simple trend towards greater flexibility, period (Sayer, 1990: 26).

For Clarke:

> The past decade has not so much seen a restructuring of the regime of accumulation, based on the development of post-Fordist forms of production, as a sustained offensive against the working class, aimed primarily at the destruction of the institutional forms of the Keynesian Welfare State which underlay the ability of the organised working class to realise a consumption norm, based on a generalised expectation of rising living standards ... While Keynesianism was the ideological expression of the attempt of capital and the state to respond to the generalised aspirations of the working class, in the post war boom, neo liberalism is the ideological expression of the subordination of working class aspirations to the valorisation of capital (1988:37).

The recovery of the late 1980s is not based on the development of new forms of production but sustained on the basis of the mass devaluation of capital and destruction of unprofitable productive capacity along with associated offensives against the organised working class. As one senior corporate manager I interviewed made clear this recovery has been sustained primarily by the intensification of labour:

> Lets make no bones about it one of the prime factors stimulating our own and other companies inward investments in the UK has been the dramatic turn around in work attitudes primarily fostered by the government but aided by a new economic realism and insecure job markets ... This has enabled companies to raise productivity and invest more confidently (Production Manager, Major Car Manufacturer, England).

Regulation theory in proclaiming the latent viability of new regimes of accumulation rather than theorising the moribund nature of capitalism and its essentially pernicious mode of accumulation, unwittingly provide the theoretical rationale for the regeneration of national economies rather than emphasising how national regeneration can only take place by confronting the barrier of working class aspirations.

Summary

In this chapter I have sought to highlight the transformative nature of capitalism and to discuss the ways in which both work organisations and broader social relations are continually changing. I have discussed the intensification of competition between firms and highlighted the key role of information technology in enabling management to restructure and rationalise work processes. At the same time I have discussed the possible impacts and ramifications of this technology and processes of restructuring on the broader social relations of production and wider society.

Many firms are taking advantage of favourable legislation, high unemployment and a new political realism to rationalise operations and tighten control over employees. Information technology enables senior management to rationalise organisations as more and more operations - from marketing through to design and manufacture - become automated or computerised. In some organisations this technology has been accompanied by even more significant cultural and political changes; where this is the case information technology is often used surreptitiously to increase the surveillance and monitoring of ostensibly `free' or `harmonised' workforces. Importantly, it is being used to raise the rate of productivity of a whole army of white collar employees who, previously, were relatively immune from employers' attempts to either control them or to routinise their work.

In the following chapters I examine in detail the role of engineers and systems analysts as key `change agents' within this process of restructuring. I shall be arguing that although neither engineers nor analysts are the blind agents of capital and, in fact, possess a significant degree of autonomy within the design process, their designs nonetheless often reinforce the dominance of capital over living labour within the production process.

Engineers Values, Methods

and Role in The Design Process

Introduction

Engineers and systems analysts are two key groups of workers central to the process of business restructuring discussed in chapter one. It is they who design the technologies, and implement, maintain and develop systems and infrastructure that enables business to restructure. At the same time their design experience and career opportunities are intimately bound up with this process of restructuring[1].

Neither engineers nor systems analysts roles within the design process can be fully understood without reference to this broader institutional context of change. Both engineers and analysts articulate and justify their own particular work activity by referring to this broader institutional context and work in the context of a complex web of values and methodologies which are tested, contested and reassessed in this changing world[2].

In this chapter I address two issues Firstly, factors which may account for the tendency amongst engineers towards designs which devalue, downplay or deskill human labour (Braverman, 1974, CSS, 1981, Noble, 1984, Rosenbrock, 1986). Secondly, the impact of engineers' practice, values and methods upon the work of systems analysts[3]. Engineers constitute an interesting social group in their own right, standing as they do at the forefront of systems design broadly defined. No analysis of the process by which technologies come to be constructed can be complete without an exploration of this key social group.

Do those designing and delivering technology consciously seek to provide capital with the means for 'disciplining the industrious classes'? How does capital translate its 'interest' into physical artefacts and manufacturing processes? How does it secure the co-operation of engineers and designers in this process? Do these engineers and designers automatically recognise, accept or acquiesce to 'capital's interest', or do they challenge it?

I will be arguing that an analysis of technological artefacts of the last two hundred years discloses the operation of a dominant ideological paradigm: distrust of the industrious classes and a need to control them, coupled to an often inhuman disregard for the people operating such technologies. However, I do not wish to maintain that all engineers and technologists *per se* are responsible for this situation; rather some of them are both the medium and mediators of such an ideology, as well as its victims.

My research indicates that there is consistency in the design and development of technologies geared towards the control and manipulation of human labour so as to intensify its exploitation. However, it is too simplistic to ascribe to all those responsible for such designs anti-workerist, pro-capitalist interests. I found that quite often engineers could be deeply troubled by the types of system they design:

> To be honest, it would drive me crazy having to operate these blow moulding machines ... It is mind numbing repetitive work ... It must drive the girls crazy operating them.... *[Why build them like this?]* ... Well, er, it's designed this way - cost benefited this way. [*Really?*] ...Well, er, I suppose the intention is to keep

> wage costs down ... and give management control ... Well, there's no suppose about it, is there? ... But it's not a reasonable work system [and] no human being should really have to live like this ... Its not ideal [and] I'm not proud of it ... but this is life (Production Engineer, Plastics Manufacturer, Wales).

Historically, engineers have proven to be quite critical of capitalist society and of individual capitalists. Thus, as Stabile (1987) and Meiskins (1983) argue, at the turn of the century, Veblen and sections of the American Electrical Engineers castigated the bourgeoisie, who were seen as parasitic and irrelevant to the organisation of production. Engineers argued that they knew best how to organise and control production which they perceived as an essentially technical process thrown into disruption by the operation of the market.

If we are to impute to engineers *per se* an anti-workerist mentality derived from their acceptance, wholesale or otherwise, of a pro-capitalist mentality, then what might that mentality look like? Also, by what means is it assimilated or reproduced? Finally, how then do we account for the similarity of designs in non-capitalist social formations in Eastern Europe prior to recent reforms? Lenin (1965), for example, believed that there was much that was progressive in 'scientific management'. If Marxist leaders like Lenin can abstract 'science' and 'methods' from its social relations of production, then we should not be too hard in our condemnation of engineers for committing an equal error and seeing in the methods of engineering a notion of abstract 'progress' and 'science'. Furthermore, engineers are no more immune from the commodification of social life and work processes than anyone else. That capitalism appears on the surface to be an exchange of free equivalents - labour for an equivalent wage - and accumulation merely a technical process, is an illusion which most share. Criticism of this forms the basis of Marx's analysis of this mode of production and examination of the production of surplus value. It is not unreasonable to assume that many engineers and technologists, just like most others, fail to understand the commodity forms through which capital generates surplus value and, thus, see the organisation of production as natural and non-exploitative.

I shall argue that there is in engineering a set of values and methods which, though not mechanically derived from some notion of capital expediency, can act to reinforce capitalist social relations. These values and methods are produced in specific historical conjunctures. Some predate the development of capitalism itself, arising out of the interplay of a variety of social forces and cultures. Others represent more conscious attempts, particularly of large corporations, state agencies and professional bodies, to disseminate a particular world view amongst engineers.

Drawing on interviews, case study observation and literature reviews I have been able to document several major methodological approaches and value systems which inform the types of technologies and work systems which engineers design[4] and which, when utilised, either individually or together, act to constitute a design culture or engineering system which can serve to both legitimise engineers practices and act to reinforce worker subordination within the design process. These approaches are formal theory, analytic theory, Taylorism and methods time measurement, control and systems theory, productivism, design purity and technological determinism[5]

Formal Theory

Design is premised upon quantifying, standardising and controlling matter. This matter, however, by its very nature, exists only through process of continual change and transformation. Ironically, the very subject matter that constitutes the 'science' within engineering - for example, thermodynamics, with its emphasis on the continually changing states of solids, liquids and gases - is routinely forgotten when it comes to creating engineered states, be they specific technologies or entire production processes which call for order, control and stability[6].

As a result of the application of formal logic, an approach to engineering and design has emerged based around notions of constancy, stable systems and control. The objective of the design remit is to achieve an 'engineered predictable steady state', be it the balance of human and machine feeds on a manufacturing line, or the specific working tolerances of a bearing on a crankshaft. This is clearly indicated in the following commentaries of three very different engineers I interviewed, the first complaining about the difficulties of line balancing:

> We seek to impose order where disorder is the norm. (Production Engineer, Automotive Components' Manufacturer, Wales).

The second is conscious of the contradiction between theory and practice:

> We have subject matter, like thermodynamics and fluid mechanics, the entropy law, etc., which inform us of the changing states of solids and liquids and the volatile nature of matter ... In reality, however, we must seek to hold fast that which moves, constrain that which changes, predict the unpredictable ... because we are engineers (Director, Artificial Intelligence Centre, Scotland).

The third highlights the problems that can emerge when design is premised on a formal basis:

> I work with quantities ... Everything is reducible to a symbol - length (l), mass (m), thermodynamic temperature (t), etc., [and] my lads have access to whole volumes of calculus and conversion tables ... [When] a project comes in, work is assigned to each member of the team, who then start working out the calculations, moving to ever finer levels of abstraction, until we are satisfied that each phase of development of any particular component is 100% tested ... But I suppose each mathematical refinement, each ever more sophisticated model is ... a kind of bucking of reality ... We froze it for a moment and tested a specific piece of it in abstraction from the whole and it all added up nicely ... we congratulate ourselves ... but when the clock starts again [and] when we get feedback from the customer and user, we hear the part failed, it dulled too quickly ... and our solution? Go back to ever more sophisticated calculus and programme for every conceivable contingency, using our latest simulation and graphics packages ... Something's wrong somewhere (Design Engineer, Pharmaceutical manufacturer, Scotland).

What these engineers are touching upon is a profound contradiction and antagonism, embodied in engineering methods and practice. It is an antagonism expressed in the predominance of formal logic within our society and within the scientific and engineering culture in particular[7].

Mannheim (1973) argues that this leads to a situation where one no longer asks what one would like to know and what would be of decisive significance, but attempts to deal only with those complexities which are measurable, according to already existing methods[8].

Western engineering philosophy rests unwittingly on formal logic, which, according to Novack (1978), is the Aristotelian logic of the simple syllogism which starts from the proposition that `A' is equal to `A', a postulate which is accepted as an axiom for a multitude of practical human actions and generalisations. In reality `A' is never equal to `A'[9].

The axiom `A' is equal to `A' on the one hand appears to be the point of departure for engineer's knowledge and understanding, yet on the other hand, appears to be a major source of frustration, misjudgement and, indeed, error in design. Every machinist knows that it is impossible to make two completely equal objects. In the elaboration of bearing brass into cone bearings, a certain deviation is allowed for the cones, which should not, however, exceed certain limits, i.e. tolerance. By observing the norms of tolerance, the cones are considered as being equal when the tolerance is exceeded, the quantity goes over the quality and the cones are useless (Novack, 1978). An engineer designing cones and bearings can successfully calculate tolerances but he or she cannot always ensure that they are met in manufacture. Whilst incorporating tolerance in the design of a bearing is relatively straight forward, trying to engineer speeds and feeds on a production line using the same philosophical approach is fraught with far more problems, e.g. knowing precisely which series of quantitative analysis are going to bring about which type of qualitative change.

The critical assumption of formal logic is constancy: the need to engineer stable states. Mathematical models are constructed on the basis of formal logic to express, in numerical form, specific fixed states to enable calculations to be made on them. Once each abstract fixed state has been calculated and checked, it then becomes a matter of merely releasing the 'time freeze'. However, matter exists in time, and time and matter are continually changing. It should, therefore, come as no surprise that when frozen fast models are released, in time, they are often out of touch with changed realities. This argument was captured neatly by one of my interviewees:

> One of the problems with traditional systems design approaches, is that the actual method by which you compiled information on current user practices, was highly dogmatic ... Projects tended to be driven from the top [and] too many unwarranted assumptions about the form and content of users work went unchallenged ... We would often assume, for example, that any particular user actually did the work as specified in the formal job remit, in reality all kinds of problems emerge [because] users do not always work to the book. In fact, they never work to the book. They may sequence their work in illogical fashion, do a variety of overlapping tasks, etc. ... We spent far too much time compiling statistics and information on the basis that the user environment was constant and readily knowable [and] no sooner had we spent thousands [of pounds] building information systems on the basis of this data than the system was outdated or only partially accurate ... The emphasis today, is on user generated systems using support software, visual displays, modelling and prototyping, etc., which, I suppose, is an acknowledgement that our existing methods and practice were out of date ... The aim now, is to build systems real time, interactively with users ... This has been quite a revolution in systems analysis and design (Industrial Engineer, Heavy Electrical Engineering Company, Scotland).

Analytic Theory

Reinforcing the 'formal logic' approach are two other notable value systems which impact upon western engineering and science. The first is what Hales (1982) terms the 'Scientific Revolution' which is a commitment to seeing the universe in mathematical and increasingly quantifiable terms, part of a general movement of empiricism emerging in the 16th and 17th centuries. The second has its specific location within capitalist relations of production and is geared around prediction and control (Marx 1981, Marglin 1974, Braverman 1974).

The analytic approach is premised on the supposition that if each part of the system is perfect, the aggregate of the parts or the whole should be perfect as well. The fundamental assumption of this approach is that if we understand each part very well, we will also understand the entirety very well. This approach to design is microscopic and anatomical, focusing on individual parts and understanding the whole by dissecting it into its constituent parts. Intrinsic to such an approach is a recognition of the impartiality of the scientific and a faith in pure reason: so long as we study something long enough and hard enough we will solve its mystery. It is an approach emphasising analytic detachment and order.

Yoshida (1989) argues that western designers and manufacturers severely proscribe the system being built via detailed analysis and design methodologies, detailed division of labour, close supervision and tight control. This argument is supported explicitly by a number of systems analysts and engineers I interviewed:

> I think there is a tendency to dive into documentation and procedure before we really understand the more fundamental issues, like do we really need this system? What is its purpose? How will it handle change? etc. ... In my opinion this stems from the culture in which business is run, management driven, top-down projects premised upon having reliable quantitative data on each functioning part of the system ... Structured methods, and detailed analysis and design procedures, testify to this perennial obsession with trying to stick a number and a value on each aspect of the design process ... Design, in my opinion, should be more intuitive ... Good designers recognise that reality is every changing and unpredictable ... (Chief Design Engineer, Heavy Electrical Engineering Company, Scotland).
>
> We tend to get bogged down in actual methods and calculations without realising that these methods actually impose their own logic, on the way we conceptualise the project ... The methods tend to assume order and functionality at each stage of the design process and if you stick to them too closely, you will loose sight of the wood for the trees ... (Software Engineer Automotive Components Manufacturer, Wales).

In effect, tight boundaries are proscribed, in advance, for any particular project, then each aspect of it is undertaken via a detailed division of labour. Chan *et al* (1990) argue that a typical example of Western engineers` analytic and Taylorist mentality, can be found in the development of computer based Manufacturing and Resource Planning systems (MRP). In response to intensified international competition, many Western manufacturers were looking for ways of economising and rationalising production. A solution advanced by engineers and designers was MRP, a system which offered managers the prospect of tighter control over working practices and materials supply. Chan's argument is that MRP represents both the triumph and the failure of the analytic tradition within Western engineering: the notion that you understand and perfect the system - in this case, manufacturing processes - through perfecting, controlling and monitoring each individual sub-part of the whole[10].

Yoshida (1989) argues that, in contrast to the analytic approach characteristic of western engineering and management, a holistic approach predominates in Japan. This approach takes the position that even if each part is perfect, the whole may still not be perfect. The fundamental assumption being that the entirety is *more* than the sum of its parts. Synergism, or Gestalt, might be used to describe this approach. Yoshida maintains that the holistic approach is rooted in a different cultural tradition: the distinctiveness of the Japanese social formation, with its homogenous race, language and supposedly shared value system. By contrast, Yoshida argues that Americans, with their heterogeneous culture and Taylorist value system, seek to proscribe the boundaries or perimeter of the system, once rigid boundaries are defined. People then fall into a habit, or philosophy, of doing only that which is prescribed for them, i.e. Taylor's ideal:

> Under our system, a worker is told just what he has to do and how to do it. Any improvement he makes upon the orders given to him is fatal to his success (1906: 4).

This leads to a sapping of initiative and creativity within the design process, the under utilisation of skills and intensified problems of alienation and resentment (CSS 1981, Cooley 1981, Wood 1989).

Taylorism and Methods Time Measurement

Formal and analytic approaches to design are buttressed by many engineers' acceptance of Taylorist and Methods Time Measurement (MTM) inspired philosophies[11].

For Taylor, engineers would be the ones who would systematically plan others' labour and, at the same time, be the repositories of knowledge of production processes and techniques. Taylor's initial formulations of 'scientific management' were extended by the engineers Maynard, Stegmerten and Schwab into MTM[12]. Taylorist notions of manufacturing, as a science, predicated upon the creation of constant stable states and the rationale application of knowledge is taken several stages further by MTM theorists. Each operation is broken down into the movements required and the time needed. This may entail close observation and timing of workers but also draws upon a massive body of standardised data, developed by industrial engineers, concerning the way in which operations can be simplified to achieve maximum economies of motion, thereby reducing the time required for tasks. Emery (1981) argues that if we look at traditional practices in designing a mass flow line, we find that critical assumption has slipped in and has been reinforced by the widespread reliance on MTM as a planning tool. This assumption is that it must be possible for each worker to be responsible to an external supervisor for his or her individual performance. On this assumption, MTM goes beyond being a planning tool to determine the probable labour requirements of sections of the line and becomes part of the detailed day-to-day supervisory control over production. Under this impetus, fragmentation of tasks heads down to the lowest common denominator of the labour on the line. Each component part of the line is broken down, analysed and calculated, then reassembled in real time. The assumption that a line must be built up from the individually supervised one man shift unit enters the design of algorithms to determine line balance[13].

However, the practical problems of line balancing cannot be solved simply by abstracting a particular aspect from the total systems of potential gains and inherent costs of flow production. Buzacotti (1986) argues that mathematical models for line balancing, built up over a number of years, find their rationale in the decomposition of tasks in which individual units of labour are taken as a given elementary basis to enact planning calculations upon. He adds that there is no rational engineering explanation of why this should be so other than Taylorist dogma[14].

The majority of engineers I interviewed cited some of Taylor's most base assumptions about work design and human motivation:

> This plant is designed on the basis of mine and management's experience of MTM ... Each component part of the plant has been analysed by myself and colleagues

to determine, using MTM, the most efficient combinations of manning, equipment utilisation and materials throughput ... It is a painstaking job, requiring a large quantity of calculations and high level mathematics [and] neither I, nor my colleagues, can concern ourselves with human issues ... Operators are considered as working units [and] they are there to work, to do as they are told ... If I went out on to the floor and said, "Hey lads, how would you like this new system to work?", fifty percent wouldn't have a clue and the other half would want all kinds of luxuries ... I design on the basis of hard facts, not psychology (Production Engineer, Automotive Components Manufacturer, Wales).

The way I see it [is that] it does not make good business sense to devolve power to workers ... Why design in control and skill when all they will do is turn around and blackmail the company ... wanting more pay and recognition? ... My personal view is that, where possible, automate as much of the production process as possible ... That way you get rid of uncertainty and get in managers' good books (Graduate Electrical Engineer, Large Public Utility, Scotland).

It is possible, as Smith (1986) argues, that many graduate engineers loose an appreciation of the skills and culture of shop floor workers which, previously, were held by those engineers who came up through the traditional seven year craft apprentice route. However, this still does not locate the seeds of this anti-labour culture within specific forms of theory and practice. An example of this is control and systems theory, or case study and project working, where engineers are rewarded for economising on labour costs or better, eliminating labour altogether:

In my opinion, there is an unwritten code of practice, within certain branches of engineering which automatically perceives the workforce, or human element, within any particular system, as a weakness [and] a source of possible error and frustration for the engineer ... I had an old lecturer, who was adamant that good engineering seeks to control and tightly specify the operating unit - his term for the worker ... I suppose he was a classic Taylorist ... But even today, in newer engineering disciplines, this same distrust is felt ... and probably exacerbated by the inclusion of managerial and accounts based subject matter and this perennial push for business awareness (Chief Design Engineer, Heavy Electrical Engineering Company, Scotland and also University Course Validator).

The Council for Science and Society (1981) has argued forcefully that Taylorist and MTM inspired approaches to design are counterproductive in that they lead to the creation of alienating forms of work, under-utilisation of operator skills and creativity. They add that these approaches break the learning curve between theory and practice, leading to the destruction of intelligence within the production and design process. Some of the strongest criticisms of Taylorist and MTM inspired engineering and management practice has come from industrialists:

> We are going to win and the industrial West is going to loose out [and] there's not much you can do about it because the reasons for your failure lie within yourselves. Your firms are built on the Taylor model. Even worse, so are your heads ... with your bosses doing the thinking while workers wield the screwdrivers. You are convinced deep down that this is the right way to run a business. For you, the essence of management is getting ideas out of the heads of management and into the hands of labour ... We, however, are beyond the Taylor model. (Mr. Konasake, Executive Director, Matsushita Panasonic, cited by Tribus 1989).

The argument is that Japanese manufacturing has competitive edge because it is capable of producing higher quality goods, at comparable prices, because it has supposedly abandoned Taylorist forms of work organisation and design. These are replaced with a variety of co-operative and harmonised work philosophies and work relations, whose central premise is the recognition of the value of the shop floor worker and the need to tap into human creativity. Whilst managers like Mr. Konasake, may be well aware of the failings of traditional Taylorist work organisation and design philosophies, the same cannot be said for the majority of engineers I interviewed, who were still steeped in a Taylorist culture and tradition of design predicated on tight control and preferably elimination of the 'operating unit'.

There were, however, a few notable exceptions:

> If we want to remain competitive with the Japanese, we have to seriously reconsider the way we go about engineering and designing products ... I have visited a number of Japanese companies, including Nissan, and their approach to design is far more open and intuitive ... All along the line they get feedback [and] design is less compartmentalised ... Designs are discussed, employees and customers are brought into the discussions, their opinions are actually sought ... The layout of the lines necessitates far greater employee involvement in quality inspection and trouble shooting and they are rewarded accordingly (Production Engineer, Defence Contractor, Scotland).

Whilst Taylorist attitudes to design and work organisation were common amongst engineers I interviewed, these ideas were not always thought through nor were they always the dominant ideas; they were open to challenge and there was variation:

> We will need to be far more innovative and open than we currently are....Somebody has got to bite the bit and bring about some dramatic change before we are all out of a job....The way I see it, Taylor has had his day....It was all right for a time but things have changed [and] industrial relations have changed. As engineers we need to change with the times and be more innovative in the ways in which we approach design (Chief Design Engineer, White Goods Manufacturer, Scotland).

Much would depend on which particular engineer one was referring to, for example, production or electrical, personal background, or types of projects he or she had worked on, etc.. Thus, one graduate electrical and electronic engineer, who was working in the aerospace industry, recalled the following experience of working on a robotics project with a number of different workers both within his own and other companies:

> At university, we never paid much regard to the worker or issues like the quality of working life ... Ergonomics was always seen as a soft option and rather girlish [and] it was always implicit that worker involvement in design was fraught with danger ... Two years ago, I began working as part of a larger team on telechiric devices to be used in hostile environments, like radioactive situations, bomb disposal, noisy or polluted work environments, etc. ... Much of the work involved talking to users, getting hands on experience of their work, discussing their fears and worries and helping them to be forthcoming about the technologies being suggested and how they could be improved ... The whole thing for me was a learning experience and immensely rewarding ... In one factory, I was working with a small group of girls on a line handling toxic chemicals. Getting to appreciate their job, its dangers, and their fears over loss of skill and their need to feel useful affected me ... It's a humbling exercise ... I will never feel the same again about design and all that Taylorist power shit (Electrical and Electronic Engineer, Aerospace Industry, England).

Engineers live in a changing world, their perceptions of that world and the values they hold are continually being tested. Whilst Taylorism may be a dominant engineering approach, it is not uncontested. Its rationale is questioned, by at least some engineers.

Control and Systems Theory

Noble (1984) argues that engineers' ideology of control

> ... emerges most clearly as a motivating force, an ideology in which the distrust of human agency is paramount and in which human judgement is construed as human error. But this ideology is itself a reflection of something else: the reality of the capitalist mode of production. The distrust of human beings, by engineers, is a manifestation of capitals distrust of labour. The elimination of human error and uncertainty is the engineering expression of capital's attempt to minimise its dependence upon labour by increasing its control over production. The ideology of engineering, in short, mirrors the antagonistic social relations of capitalist production. In so far as the design of machinery, like machine tools, is informed by this ideology, it reflects the social relations of production (1984: 6).

Noble, however, fails to explain adequately how engineers come to hold this ideology and how it might change over time. He portrays an omniscient capital, with only one interest *vis-à-vis* labour which has somehow moulded engineering values. Absent is any sense of dynamic and engineers are presented as the passive recipients of a dominant ideology rather than active shapers of ideologies. The conditions giving rise to the formation of particular ideologies are constantly changing. Discussion of control and system theory must be sensitive to processes of change within capitalism and within engineers' practice and perceptions, otherwise engineers are simply reduced to direct, unwitting, agents of capital.

The development of control and systems theory within engineering is intimately tied into the development of the capitalist labour process and, in particular, to the historical development by early innovators, manufacturers and business of a vocabulary of deskilling premised on distrust and contempt for the working class. Technology historically has been used as an instrument to wrest control of the labour process from the worker (Marx 1969, Braverman 1974, Levidow & Young 1981). Much of the literature accompanying the development of the automatic machine process was couched explicitly in terms of providing employers with the means to exercise greater control over labour and to prevent labour's independent initiative and control over production processes. This was the rationale, Ure argued, in the invention of the self-acting mule, 'A creation designed to restore order among the industrious classes' (cited by Levidow & Young 1981: 22). It is the assumption behind much of the advertisement and sales literature for early machinery and it is the explicit philosophy of scientific management and early developments in control and systems theory.

Boguslaw, for example, argues:

> Our immediate concern, let us remember, is the exploitation of the operating unit approach to systems design, no matter what materials are used. We must take care to prevent this discussion from degenerating into a single-sided analysis of the complex characteristics of one type of systems material: namely, the human being. What is needed is an inventory of the ways in which human behaviour can be controlled and a description of some of the instruments which will help us to achieve control. If this provides us with sufficient 'handles' on human materials, so that we can think of them as one thinks of metal parts, electrical power or chemical reactions, then we have succeeded in placing human material on the same footing as any other material and can proceed with our problems of systems

> design ... There are, however, many disadvantages in the use of human operating units. They are somewhat fragile; they are subject to fatigue, obsolescence, disease and death; they are frequently stupid, unreliable and limited in memory capacity. But beyond all this, they sometimes seek to design their own circuitry. This, in a material, is unforgivable. Any system utilising them must devise appropriate safeguards' (1976: 88).

Control and systems theory as engineering science is little more than an articulation in mathematical form of the antagonism of interest between capital and labour that exists within the capitalist mode of production. That early proponents of such theory were so open about the need to control labour, to subordinate it and teach it docility, reflects the starkness of conditions in which the early machine process was being developed. Vocabularies of systems design premised on the open and direct subordination of labour and strategies of outright scientific management may have been appropriate to an earlier period of capital accumulation but are a political and economic liability within certain branches of production and certain social formations today. Employers and politicians alike have to be sensitive to a variety of interest groups and changed cultural perceptions about the form and nature of work (Thompson 1995, Marsh 1995, Berggren 1989, Clarke 1990).

How has control and system theory adapted to the changed conditions in which engineers work? The vocabulary of employers` inalienable rights to exploit workers as they feel fit is gradually disappearing, at least in certain social formations; and a wider vocabulary, emphasising labour's special or unique contribution to the total system, is slowly emerging within engineering. The basic philosophy underpinning control and systems theory, however, has not really changed. Human beings are still seen as component parts of a system. Systems should be designed to emphasise the functional unity of parts; humans are still recognised as possibly 'difficult' or 'dysfunctional', to be handled by either elaboration of more sophisticated systems concepts, for example, contingency approaches to design (Willcocks & Mason 1987) or through the input of greater quantitative variables into the final system equation to be handled by the computer. In short, human beings now have to be considered more fully if complex manufacturing systems are to function, but they are still regarded with distrust, as problem areas, and, consequently, in need of control or preferably elimination by designers.

The majority of engineers I interviewed and observed did, indeed, display many of the attitudes to control that Noble indicates. However, a number were also critical of those structures of control and the implicit assumptions of deskilling and automation that went into engineering design:

> There are systems I would have liked to design. For example giving greater control to certain operators over CNC machining, so as to be able to tap into their accomplished skills and years of experience [and] also to enhance their job satisfaction ... I thought flexible manufacturing here would follow this path but it hasn't ... Management merely want to replace the skilled machinists with YTS overseers and keep all design within engineering ... Personally I disagree (Mechanical Engineer, Pharmaceutical Manufacturer, Scotland).

Another engineer complains that open systems design can get too complicated and political and that he prefers the comfort of a more proscribed design remit:

> All design, however small, is conceived in terms of a system ... It's a view of the world where we look at the relationship of a particular component, or change in one aspect of the system, on the totality of the system ... [A big system] requires one to think systematically, trying to consider the variety of physical and non-physical inputs required, their ratios, quantities, impact on other systems components, etc. ... it can all move into politics and industrial relations and become very messy ... I'd rather stay where I am and just focus my skills on solving particular technical problems (Electrical Engineer, Large Public Utility, Scotland).

Control and systems theory are two general theoretical approaches to design within engineering. Both approaches are most prevalent in production and industrial engineering, but are also prominent in the vocabulary of engineering generally. Certainly, graduate production or industrial engineers will have been exposed to these theories. Burns and Fitter (1987) argue that, for many industrial engineers, explicit or implicit system definition is included as part of the design assignment. Boundaries of a system are established by specifying the components included within the system, the inputs to it and the outputs from it. Two key elements to system design are the selection of parts of which the system is composed and the arranging of these parts in some kind of pattern, in space and time. The degree of autonomy of the industrial engineer, at this stage, can be immense. For example, the engineer may have the choice of both physical and non-physical elements of the system, their relation to each other, speed and intensity of work and the degree of control, skill, feedback and input.

> I designed everything around you, even the relationship of this office to the shop floor ... Two seconds is all it takes for any manager to get out there and keep an

> eye on work progress ... the materials, suppliers, precise quantities of labour and skills ... the ratio of men to materials, their specific utilisation and in what quantity ... The technology and training required was all determined by myself with the assistance of colleagues ... It gives me satisfaction ... I didn't need some snotty-nosed consultant to do it for me, I followed basic engineering principles (Production Engineer and MD, Chemical Company, Scotland).

Burns and Fitter (1987) argue that systems consist of parts, or components, of which there are three types: structural, operating and flow. A structural component is one whose principle function is to maintain the necessary relationships of the parts as a functioning whole, for example, the casing of a watch. The structural component of a system serves to locate, constrain and shield. The operating component of a system has two distinct parts: men and machinery. The allocation of tasks between them is a frequent requirement of industrial engineering design. The physical components exist to serve the system in which they function, whilst human components have purposes of their own, apart from and outside of any particular system which

> operates more effectively as fundamental individual interest of well being and even personal survival are subordinated more completely to the system interest (Burns and Fitter 1987: 94).

The flow component of a system is the ratio of time and rate of movement of the system components, its inputs and outputs. The problem of specifying flow and time standards for human performance, within a system, constitutes one of the industrial engineers most challenging tasks. He or she must make judgements on the suitability and variability of various personnel, including their mental and physical properties, and the minimum levels required for the performance of duties.

The purpose behind utilising systems theory is to achieve a steady controlled state. Control is perceived by engineers, as that which guides, directs, regulates and constrains[15] Out of twenty engineers I specifically asked about `open' and `closed' loop systems fourteen said that they would prefer to design closed loop systems on the basis that this would eliminate the uncertainty of including human agency and be a 'better engineered system'. Only one engineer openly espoused the benefits of an open loop system:

> Manufacturing is moving real time [and] our business has seen rapid changes these past few years as we move towards zero inventory, zero defect, zero stock ... JIT manufacturing requires you get quality right first time. It requires you have adequate feedback on the state of play within any particular system. You can inbuild this electronically ... but this does not give you the flexibility that well trained people do ... They bring a variety of sense and experience to the process and, unlike most technology, readily learn to adapt and distinguish between what's important and what isn't (Senior Production Engineer, Pharmaceutical Manufacturer, Scotland).

It is ironic that the growth of systems and control theory within engineering was boosted by developments in what can only be described as crudely functionalist sociology. Engineers utilised Parsonian models of system and functionality to construct their own models of manufacturing relations and the role of engineers within the process of design. Systems and control theory in engineering has not yet escaped its functionalist origins.

Cohen (1968) argues that functionalism tends to treat societies or social wholes as having characteristics similar to those of organic matter or organisms. In one sense, functionalism is anti-reductionist, emphasising the systemic nature of social wholes. As Brown (1992) stresses, these wholes are then perceived as involving differentiated units which are interdependent, and this raises two related questions. How is the independence of units effected? What contribution do the parts make to the whole? Explanation is sought through a detailed examination of the functions of the parts, for the maintenance of the whole, at the same time, emphasising how form is appropriate for such functions.

However, this system - of finely engineered equations determining flows and human agency inputs - is unpredictable. As Burns and Fitter note:

> The problem of balance between human individuality and the benefits of a stable, reasonably efficient and reasonably predictable operating system ... has profound philosophical aspects and subtle practical difficulties (1987: 95).

The CSS (1981) argument for a systems theory approach to design is premised on being able to calculate, quantify and predict component parts of a particular system and then creating, on this basis, suitable mathematical models which, by process of ever greater abstraction, approximate to reality. The logic fuelling this approach to systems design is implicit in recent attempts to use computers, in engineering, to generate new technological systems. For example, De Neufville and Stafford (1974) document a series of mathematical techniques such as production functions and marginal analysis that can be used to generate good systems design, assuming that the input data is 'correct' and that the quantities collected when worked upon will provide an accurate qualitative picture. They assume that having access to powerful computer based modelling tools will produce superior designs. However, this is not always the case.

> Modelling software has its uses but only so far ... In my opinion too much emphasis, within engineering is placed on assuming the validity of data received ... It is taken as a given ... Somewhere along the line someone went out and gathered raw data ... But how do they know the data they gathered is accurate? ... How do *you* know it's accurate? ... The only way is to immerse yourself in the user environment, talk to people, even do their tasks yourself ... Today, too much design is dictated by the modelling methods and too much emphasis is placed on quantitative, as opposed to qualitative, design experience ... (Software Engineer, Public Service Institution, Scotland).

Algorithmic methods of problem solving require predictability, repeatability and quantifiability. Cooley (1983) argues that the quantitative information designers amass, before making qualitative judgement, is extremely complex and that the crude introduction of the computer into the design process by management results in a deterioration in design quality. Wheale argues:

> Algorithmic methods reduce the decisions left to the operator of the system to routine choices between fixed alternatives. Similarly, computer systems used to systematise building design, by arranging predetermined elements on a visual display unit, in order to produce different build configurations, limit creativity in the job to choosing how the different elements will be disposed, rather than considering, in an open ended way, the types and different forms and materials that might be used (1983: 204).

Cooley (1987) argues that this conditioning of technologists by traditional design methods leads them to downplay broader systems theories, and to underplay human skill and ingenuity - which tends to be seen as dysfunctional and in need of elimination from any particular system[16].

A number of engineers I interviewed viewed the drive towards *ad hoc* computerisation and increasing reliance on quantitative modelling techniques as leading to a situation of design sterility within engineering:

> We have CAD/CAM and we also have some very sophisticated design software ... But the software is only as good as the guy using it ... [*Presumably also only as good as the person who designed it?*] ... More... It takes longer, you get bogged down in key strokes, programming routes, the process of instruction [and] a logic is imposed by the software which does not necessarily facilitate creativity and fast route brainstorming ... I think it also prevents us communicating with each other ... (Design Engineer, Automotive Components Manufacturer, Wales).
>
> Everyone here uses quantitative statistical techniques for building up models or scenarios of how a particular system will operate ... It's amazing, I've had lads in my department, who when questioned about a component they have designed on screen and which, in practice, has been found to be wanting, turn round and say that they are right and reality must be wrong. I remember one gentleman who got a real bollocking ... He took me through his entire design route, every little equation on every stage of the design, pointing out that he had followed the methods to the letter. "Yes,", I said, "but that isn't engineering. What you failed to consider in your equations is the fact that this equipment was going to new customers, who were very brutal and heavy handed with it ... Maybe, if you had torn yourself away from the screen, and actually visited them and watched the equipment being used, you would have built the casing and switches differently!" (Chief Design Engineer, Heavy Electrical Engineering Company, Scotland).

Wheale notes:

> It is ironic that cybernetic techniques are now used in some firms to help stimulate individual and work group creative thought when it is the very philosophy behind cybernetic control which has aided transfer of the discretion in work from the worker to management. Indeed, creativity techniques, such as brainstorming and synectics, may be seen as treatments for people in a society suffering from general repression of its imaginative and creative abilities (1983: 204).

The adoption by engineers of a system approach to design was part of an advancement of general systems theory which, according to Brown (1992), aimed to show how concepts and assumptions could be used to analyse phenomena in a wide range of fields of scientific enquiry and to develop a new scientific doctrine concerned with the principles which apply to systems in general. General systems theory was seen by many engineering educators as relevant to the design of technological systems. Engineers were particularly drawn to its utilisation of organic analogy and the notion that systems could `stabilise' themselves. Within this perspective systems are conceived as 'open', with the connotation that they continue to exist because they exchange materials with their environment reorganising towards states of greater heterogeneity and complexity. In such a model, attention focuses primarily on the exchange across the boundaries of a system and the input-throughput-output process, whereby the system maintains and 'stabilises' itself within its environment. The model also focuses on the feedback mechanisms through which homeostasis can be secured.

Whilst early engineering systems theory tended to operate on a very closed system model, perceiving the system as one of relatively static equilibrium, this approach was soon found lacking. Engineers increasingly were asked to design ever more complex manufacturing processes and to deal with an increasing number of problems related to systems design. For example, they attempted to maintain quality and to combat monotony and worker alienation on the line. This, in turn, would meet the demand from labour for more enriching jobs and would provide management with more interactive feedback and control over ever more complex processes. Closed loop models proved increasingly dated when dealing with this changed social context.

Given this context, engineering systems theory began to make a slow and painful transition from a closed, to an open, systems approach. Roethlisberger and Dickson (1939), in their analysis of the early Hawthorne experiments at the Western Electric Company, identified - possibly for the first time - the 'informal' organisation of an industrial enterprise. This was a big step forward from the reductionist and closed systems culture of Taylorism which assumed that workers worked to the manual and that organisations could be planned and work executed with scientific precision[17].

Systems theory received new impetus from the work of the Tavistock Institute of Human Relations set up in 1947. Jaques (1951) highlights how the pattern of social activity in an organisation is the outcome of the interaction of the firm's 'social structure' seen as essentially recognisable and stable, its 'culture' (customary tradition and ways of thinking and doing things) and members 'personalities' and their total psychological makeup. According to Kelly (1978) a major preoccupation of the Tavistock group has been to clarify and to specify clearly the roles, relationships and allocation of authority and responsibility within these systems.

Jaques' earlier work was expanded on by Trist and Bamforth's (1951) research into the longwall method of coal mining. For the first time, the concept of a production system as a 'socio-technical' system is introduced. Trist argued that open system theory (derived from the general systems theory of Von Bertalanffy (1950)) and socio-technical theory were mutually supportive, the latter being a logical extension of the former. Brown (1992) stresses that the open systems concept focuses attention on the exchanges which take place between the organisation or system and its environment: on the import-conversion-export-process. This implies the property of 'equifinality', that is, being able to achieve a steady state from different initial conditions. The technological component is seen as playing a key mediating role in the process of defining the boundary conditions under which a steady state can be achieved. A key operational concept within the socio-technical approach is the notion of 'primary task'. This is the identification of the primary task of an organisation as the starting point for investigation and judgement of the appropriateness of the organisational structure in the light of the technical, economic and socio-psychological resources within which it operates. Trist and Bamforth argued that one of the problems of work organisation in mining was that it,

> borrowed with too little modification, from an engineering culture appropriate to the radically different situation of the factory (1951: 23).

In contrast to conventional production engineering methods, with their emphasis on maximum job decomposition and fragmentation of tasks, the socio-technical school emphasises how work groups are capable of 'responsible autonomy' and how it is not possible to control labour down the pits on the basis of 'one man-one task'. The detailed division of labour and hierarchical 'one man - one task' unit of organisation is derived from the scientific management school. Work, in practice, is team-based and highly polyvalent skills are deployed. Trist and Bamforth (1951) stress that responsibility can be laid with the group for the entire cycle of operations and that self-regulation of tasks not only creates greater worker involvement but has no detrimental effect on productivity.

According to Pasmore (1982), the Tavistock school's contributions to the design and organisation of work have been influential in forming an alternative loci of design to scientific management. Interestingly, as scientific management came under increasing criticism from the mid-1970s, a number of engineers, sensitive to the need for change, became more receptive to the socio-technical school. However, the process is by no means even or uncontested. My own research and teaching experience with engineers confirms that a common reaction to the problems of manufacturing has been to assert the need for tighter control over manufacturing processes, not through harnessing human potential within production but eliminating it, wherever possible, through further and more extensive automation:

> Unions are the source of our trouble ... Why should we pander to their demands for skill and quality of working life? ... They have priced people out of a job ... As an engineer, I would seek to automate as much work as possible and where [this is] not possible build control into the technology ... (Electrical/Electronic Engineer, recently graduated, currently unemployed).

> I think, what you will find, is that many unscrupulous employers are taking advantage of favourable industrial relations to push through further rounds of automation and tighten control over existing practices ... Information technology is allowing them to do this via the back door (Professor of Engineering and Director of Artificial Intelligence Centre, Scotland).

That the majority of engineering systems theory is so divorced from developments in broader systems theory (for example, the political contingencies and labour process approaches) and does not take on board many employers' calls for 'flexible', 'reactive' manufacturing processes, says a lot about the technicist outlook of engineering educators and the contempt often displayed in engineering curricula for the social sciences and the contribution of these to the design process[18].

The majority of engineers I interviewed adhered to a weakly functionalist interpretation of systems design. There was little evidence of any sweeping change in engineers' design philosophy. The majority had only just come to terms with discarding their Taylorist crutches and compared to the computer systems analysts interviewed displayed decidedly wooden organismic models of organisational behaviour and broader systems design issues.

As Brown argues:

> [The most] Basic criticism of systems approaches in the strong form of socio-technical systems theory, or functionalist sociology, is that they reify the organisation and do so in ways which are illegitimate and misleading. That is, they treat it as a 'thing', an entity which can have aims and needs distinct from those of the individuals and groups which compose it, and can act on its own, as it were, independently of the decisions and instructions of some of its members (1992: 82).

Rice similarly asserts:

> Open systems live by the exchange of materials with their environment and have the capacity to reach a time independent steady state ... Once the steady state is disturbed for any reason, the system will exert forces to restore it ... Any healthy system will resist change (1963: 262).

This conceptualisation of the inherent characteristics and behaviour of systems, regardless of the nature of the individuals, groups and classes who compose them is too simplistic and functionalist, failing to appreciate the ways in which organisational goals, rules, roles and order are continually negotiated and re-negotiated in the active struggle between organisational members (Silverman 1970).

As Brown argues of the socio-technical approach:

> If, as Jaques claims, levels of responsibility can be measured precisely; if levels of pay which are felt to be fair can be objectively determined, for each level of responsibility; if individuals have innate capabilities which determine the level of work (i.e. responsibility) with which they can cope effectively and without undue anxiety; and, if individuals can be allocated to jobs appropriate to these capacities; then there is a basis for resolving conflicts about wages and salaries ... The conceptualisation of an industrial organisation, or business enterprise, as a unified system with a clearly identifiable goal, or primary task, and with activities and

> relationships appropriately structured to accomplish the task, makes it difficult to provide a satisfactory account of conflict within the organisation (1992: 62).

Systems theory in its organismic, functionalist and more open socio-technical forms is essentially conservative, offering an ideology of crisis free manufacture. It is merely a question of the engineer creating the right conditions for the system to reach a state of homeostasis.

Burrel and Morgan caution:

> In so far as systems theorists adopt organismic models which presume a functional unity of systems parts, with certain imperative functions which must be satisfied, if the organisation is to survive, their analysis is constrained by the requirements characteristic of a managerial point of view. It is this consonance between the nature of the organismic analogy and the requirements of managerialism which underwrites the dominance of organismic models within the field of organisation theory (1979: 219-20).

Productivism

A significant number of engineers I interviewed conceptualised their work in productivist terms. By productivist I mean that these engineers defined their own labour in terms of physically producing or making artefacts, and obtained a sense of worth and purpose from their direct involvement in making physical products. Like many of the systems analysts I interviewed, they often used the vocabulary of the 'coal face', thus making analogous comparison with manual workers, in contrast with those involved in supervision or managerial roles:

> Unlike much of management, stuck in the office, I see myself as a practical person, designing and building useful products [and] getting down to where the action is on the shop floor, not just dreaming up ideas and strategies but actually implementing them [and] producing something useful (Design Engineer, Aerospace industry, England).
>
> As engineers the focus of our activity is the design and development of products - whatever they may be. This is useful productive work. Without us nothing would get built and nothing would move ... Our labour is essential to society (Chief Design Engineer, Chemical Company, Scotland).

The productivist culture of many engineers serves as an heuristic, enabling engineers to define their relationship to others. In their struggle to wrest control of production processes from skilled craftsmen, early engineers sought to couch their claims to authority in terms of the possession of a superior productive knowledge 'scientific management' (Braverman 1974). In engineers' early critiques of capitalism, they used this same productivist culture to support their technocratic vision of production and society (Veblen 1988). At other times this productivist culture has been used by engineers to highlight their affinity with shop floor skilled labour, for example in joint union actions over pay and conditions, or over the design of socially useful products (Smith 1986, Cooley 1980).

However, managers, particularly in Britain, have seen this productivist culture as a prime reason why engineers should not be given strategic managerial positions seeking to consolidate divisions of labour geared around pigeon-holing engineers into 'technical' jobs (Armstrong 1987).

> Management pat you on the back when you've done a good job ... They never refrain from telling you how technically brilliant you are and how without you nothing would get done ... but that's as far as it goes. They don't offer you more responsibility [and] they don't consider your managerial potential, or the fact that you've probably done more business studies than they have ... (Mechanical Engineer, heavy electrical engineering company, Scotland).

The image of engineers as 'practical' men of science engrossed in the detailed labour of design and manufacture is a strong one. At its most vulgarised, it takes the characterisation of the man in blue overalls wielding a spanner and screwdriver, the Kevin Websters of this world.[19] At a more sophisticated level, it takes the characterisation, as Albury and Schwarz argue, of the technologist, invariably white and male, dedicated, rational and pragmatic, almost beyond the range of normal personality (1982: 108).

Engineers foster this image through emphasising that engineering disciplines are 'science' and that engineering practice is 'applied science', and through the cultural medium of manufacturing artefacts as they work upon 'practical problems' applying their theoretical repertoire as rational 'experts' to produce artefacts. Engineering journals, with their pragmatic literary style and emphasis on rationality, cultivate this image, as do the professional engineering associations, through their heavy emphasis on engineering as an applied science rather than, for example, as an art.

Stabile (1987) argues that a particularly strong image of the engineer and one dating back to Veblen is the image of the engineer as productive technocrat - a view which sees engineers as the group in society best able and most fitted to managing the modern technologically complex manufacturing organisation. Many engineers today, like Veblen over eighty years ago, still have this strong technicist view of the manufacturing process and their own labour within it. At its most radical, this view can lead to the suggestion that whilst engineers and technologists are needed, private capitalists and many managers are not, because they are seen as essentially non-productive.

> It seems to me that people who actually do the work, designing and building the technologies and planning and organising production, etc.,.....on a scientific basis ... should be the same people running the company, not some financier or fat shareholder who knows absolutely nothing about manufacture or the needs of this industry (Design Engineer, Aerospace Industry, England).

Confusion over the nature of the accumulation process and the emphasis on the technical and productive aspects of engineers' labour, produces a variety of political prognosis ranging from Veblen's assertion of the primacy and rightfulness of engineers' claims to corporate power (as the bearers of rational productive knowledge); to Edgell (1973) and Mallet's (1975) argument that engineers commitment to the higher rationality's of science and productivism will pose problems of securing managerial legitimacy, prompting engineers to go over to the side of labour, in opposition to an irrational social system.

Whilst engineers draw a sense of pride and personal worth from being involved in the design of tangible physical artefacts, they have been, and are increasingly, conscious of the fragility of such a position when it comes to advancing their own material aims. As early as 1919 professional engineers were arguing for the need for greater managerial and organisational awareness and duties. The president of the Institute of Mechanical Engineers then argued:

> If we are to maintain, or perhaps I should say, if we are to prevent further encroachments upon our established position in the engineering world, mechanical engineers must give more attention to the administration and organisation of workshops (cited by Meiskins 1989: 221).

The Finniston Report (1978) again highlighted the need for engineers to be made aware of, and taught, managerial and organisational skills, along with their development of greater understanding of business and the social context of design. The Report documented the low status of engineers and argued that the absence of engineering awareness and of any appreciation of engineering skills amongst management has led to a lack of competitiveness. However, according to Armstrong (1987), managers do not accept the premise of the Finniston Report, i.e. the importance of the 'engineering dimension'[20]. Armstrong argues that productivist ideology is seen as evidence of engineers' unsuitability for power by a management steeped in a non-productivist culture.

Gerstl and Hutton (1966), and Berthoud and Smith (1980) have shown that the majority of professional engineers are keen to become managers. Many managers, however, are sceptical about allowing them to do so:

> I think the strongest case is that of the technologist or engineer who is quite unsuited to a business career (Platt 1963:28).

Or again, Dr. Arnold's influential view of the education suitable for a gentleman:

> Rather than have it the principle thing on my son's mind, I would gladly have him think that the sun went round the earth, and that the stars were so many spangles set in the bright blue firmament (Bamford 1960: 120).

Urwick (1963) argues that, in order to establish management as a profession in its own right, it was necessary to detach it from its historical entanglement within engineering. In Britain this is precisely what happened, as a process of differentiation of tasks slowly took place. Fayol (1949) asserts that a distinction should be drawn between technical expertise and managerial expertise and that within larger organisations management should consciously divorce itself from technical and operational matters, so as better to focus on strategic goal setting and administration. Drucker (1955) takes this argument to its logical conclusion by stating that management which spends its time not dealing with strictly management concerns, is not fulfilling its role as management. Management should manage and engineers should fix machinery and sort out technical problems. Obviously, such an argument leaves room for debate as to what precisely constitutes a management concern. Mintzberg (1973) went some way to clarifying this by characterising management jobs as those encompassing figurehead, leader, liaison, monitor, disseminator, spokesperson, entrepreneur, disturbance handler, resource allocator and negotiator[21].

For engineers, like Taylor, the idea that management should be rooted in non-productive knowledge would have been unthinkable. The core of managerial expertise and knowledge was, for Taylor, the knowledge of productive processes which enabled the industrial engineer to redesign them to reduce 'waste' effort. Indeed, for Taylor, it was management's' possession of such technical knowledge that gave it their legitimate base for control over the workforce. This is a view held by a number of engineers I interviewed.

> Look ... I shouldn't be saying this, but a lot of managers in this company shouldn't be here ... They don't understand the manufacturing process, they are not involved in the day to day running of the plant, in buying equipment, solving technical difficulties, dealing with customers ... They don't even go down on to the shop floor ... so they can't understand the feelings of the workforce ... The more I think about it, I wonder just what these managers in fact do (Design Engineer, Automotive Components Manufacturer, Wales).

Armstrong (1987) argues that senior management, in Britain at least, have become divorced from the particularities of productive labour and form a key locale of the anti-technological, anti-productivist culture. Wiener (1981), Scott (1985) and Lash and Urry (1987) have also sought to isolate key anti-productivist sites and institutions within the British social formation, like the public school system or the predominance of financial and landed capital over manufacturing, and the dominance of aristocratic and landed gentry within Britain. These are said to weaken the position of engineers and undervalue the role of science and technology within British society.

Armstrong and Wiener touch upon important nerves. A picture is painted of an essentially regressive and parasitic management and a general culture of anti-productivism and under appreciation of investment in manufacturing: a ruling class out of touch with the realities of the changed competitive position of international economies and leading Britain down a nostalgic road to ruin. This image found strong support amongst a number of the engineers I interviewed:

> I am sick and tired of this government's attitude to manufacturing .. There is a lack of insight and long term investment [which is], in my view a reflection of the old gentry mentality and the short term interests of accountants dominating the financial markets and City of London ... Long term investment in design and technology is totally inadequate [and] producing a culture within engineering of dismay, and feelings of lack of recognition of worth .. and ultimately less creative projects (Chief Design Engineer, Managing Director, Chemical Company, Scotland).

Hurst (1986) argues that the dominant management education movement (MEM), with its emphasis on traditional management education and training divorced from manufacturing and technical knowledge, cannot meet changes in world competition and is holding back new ideas (for example, on flexible working, TQM, etc.) which are perceived as vital to competitive success. A similar argument is put forward by Glover and Lawrence (1986) who suggest that the education and training of managers in Germany and Japan differs substantially from that of the advocates of MEM: less emphasis is placed on control, through accounting measures, and more emphasis is placed on decentralised decision making, greater autonomy and flexibility by management attuned to the need for technological change.

As Parnaby argues:

> There has been a whole generation of MBA students who will not go near a manufacturing strategy ... They want to be in at the gin and tonic end with the financial strategy (Parnaby cited by The Engineer, 1985: 97).

Whitley (1981) argues that subjects like production engineering are not popular with management students even though they have been gutted of technological content to make them more palatable.

This anti-productivist culture has begun to permeate engineering itself, finding receptive sites among those graduates who seek to use their qualifications to get out of engineering[22]. As Asher (1984) argues, many engineering students have gone on to do MBAs and other management qualifications to get out of engineering and into Parnaby's `gin and tonic culture'.

Armstrong analyses management through Fox's (1974) theorisation of power and trust arguing that management is a high trust, high discretion activity, whereas productive activity is generally perceived as low trust, low discretion.

There are, however, a number of problems with Armstrong's analysis. Like Poulantzas (1975), Armstrong's definition of productive labour fails to grasp that what is productive under capitalism is that which secures profitability. Workers in banking, business administration, sales and management are vital to securing the realisation of surplus value, produced at the point of production[23]. Much managerial work is productive, i.e. of ideas, technologies, manufacture and its design, layout and operation. Sometimes management, may even physically operate plant. Likewise, much of engineers' so-called productive or technical labour involves varying degrees of supervision and control, formally through direct control of others' labour, under supervision; and informally, through the kinds of control structures engineers build into technologies.

> [The debate on management/engineer roles] ... makes me laugh ...I designed the layout of this plant virtually single-handedly. I had hundreds of men working under me on a daily basis ... Today, I am constantly making managerial decisions over the allocation of labour to use for particular batches and lines, organising meetings, contacting suppliers and customers, kicking ass ... and none of this is recognised by management here, as management, when it comes to being duly

> rewarded ... I have more personal responsibility here than most of the managers put together (Production Engineer, US Electronics Company, Scotland).
>
> Management may like to think the that they are the only ones making managerial decisions but they are misguided ... When we are given a broad remit to increase flexibility and labour productivity, in this plant, all the actual choice of technology and strategy is down to us: CNC over conventional machinery, robotics over manual operations, who is to do what job, what skills will be required ... Bloody hell, it was me and not the production manager who was in on the union meeting over task allocation and job definition! ... The guy who should have been doing it was playing a round of golf with clients (Mechanical Engineer, Heavy Electrical Engineering Company, Scotland).

Further, Armstrong downplays the fact that engineers *do* attain senior managerial positions, particularly in Germany, Japan, France and the USA: productivism alone cannot, therefore, be seen as a general disqualification from management.

As Duncan (1981) and Palaez (1990) argue, once whole sections of the labour process and particular branches of production have become 'commodified', labour becomes part of the collective labour of society and increasingly experiences both subordination and routinisation. This applies not only to sections of manual labour but also to management and engineers:

> I remember when I first started work here ... There was a great deal of give and take in the company [and you could use a lot of initiative, for example, over the choice of tables you used to arrive at a particular calculus, or the particular way you approached a design project, along with what types of tools you worked with ... Today, we are told which tables to use. We are given fixed design methodologies to follow [and there are] no more informal information gathering over a coffee in the canteen, or a pint in the pub ... We even have sensors on our CAD and word processing systems to monitor our output and productivity ... but even worse than this, we don't have the freedom to bounce ideas around like we used to ... I can't just get up and take a stroll down to the shop floor. I now have

> to get permission and fill in a report saying why I am going down ... and there may be no specific reason ... I might just want to see how things are progressing, or how the lads are getting on (CAD Engineer, Aerospace Industry, England).

Braverman (1974) argues that engineers are the recipients of skills won over from production workers - that they embody the penetration of capital into the production process, consciously seeking to separate the conception of tasks from their execution so as to break the power of skilled workers and prevent forms of work pacing such as 'soldiering'. Likewise, Noble (1984) sees engineers as, on the one hand, almost the blind agents of capital, embodying in their theories of control nothing more than capital's need to subordinate labour whilst, on the other, recognising the complexity of social relations surrounding engineers' work and the formation of particular philosophical paradigms.

The problem with this analysis is that it fails to appreciate the diversity, polyvalency and variety of engineering positions and tasks (Smith 1986). These range from those occupying essentially managerial roles, to those carrying out relatively mundane low level technical tasks, with a spectrum in between. This is the reality of engineering work. Engineers are not a homogenous bunch of workers experiencing exactly the same types of socialisation at work. Braverman establishes too arbitrary a distinction between conceptual work and physical or practical work. Many engineers carry out both aspects of work in the same task:

> A lot of the work I do is down on the shop floor. I may spend hours sorting out a particular fault on a machine with the machinist [while] working together, sleeves

> up [and] covered in grime ... I don't see my work as just brain work ... True I apply knowledge taught and have to go back to the office to write up reports ... But many guys on the shop floor also apply theoretical skills and have to write up reports (Mechanical Engineer, Pharmaceutical Manufacturer, Scotland).

Many workers, skilled or otherwise, perform varying degrees of conceptual work. Braverman overemphasises both the extent and the desire of capital to separate the conception and execution of tasks. He glibly assumes that all engineers have no other *raison d' etre* than to control manual labour through the exercise of their superior conceptual knowledge. One needs to be sensitive to engineers` own subordination and exploitation within the workplace both in terms of the intensification of their work, and reductions in pay, status and conditions:

> The younger engineers from university [and] they come here with such a superior attitude because that's what they have been taught ... But it's not long before they realise that they are the same as everybody else, we are all in the same boat ... There's been over a thousand job losses at this and our sister plant, engineers as well ... The knife cuts everywhere and we've seen real falls in our pay and status ... There's not the work and there's no more interesting projects in the pipeline ... In fact it's a gloomy picture all round (Electrical Engineer, White Goods Manufacturer, Scotland).

I have argued that many engineers hold a productivist philosophy. This is *not* the same as saying that they are productive labourers, as distinct to non-productive labourers - as both Poulantzas or Armstrong, in their different ways, argue. My purpose for looking at engineers` productivism is simply to document a discernible characteristic that I have identified and to explore how this may have an impact upon the systems design process.

Many engineers' productivist philosophy, like their notions of design purity, can lead to conflicts of interest. For example, a productivist desire to expand, manufacturing, science and technology or management's requirements for short term profitability which may manifest itself in a lack of manufacturing investment and interesting engineering projects, and worsening position of many engineers. At a time of mounting recession, severe job losses, manufacturing closure and rationalisation, many engineers' productivist value systems may act as a seedbed of critique and radicalism against managerial and political strategies.

Purity of Design

Many engineers I interviewed believed the adage that 'form follows function' and had very strong ideas about what constitutes good engineering and a well engineered product. Typical phrases used in engineering design departments to indicate a well engineered product are 'purity of design', 'unity of form and function', 'singularity of purpose' and 'logicality of design'. Typical phrases denoting engineers' dissatisfaction with an engineered product were: 'over-engineered', 'under-engineered' and 'lack of fitness for purpose'.

This terminology is interesting because it discloses a political position within the design process and reflects, in engineering terms, satisfaction or dissatisfaction, not only with a particular engineered product, but also with the social relations of design and production in which engineers are implicated. This is clearly expressed by one interviewee:

> Engineers do have notions of purity of form and function but these notions often get compromised on the altar of cost benefit analysis ... It does affect one's sense of pride ... I know it does mine ... There's nothing worse than doing a tacky job ... [That's] sound enough in itself, don't get me wrong ... but cost cut or too pinickity, due to having to meet too many formal requirements ... You know it's an important part of the satisfaction of an engineer's job to see his designs in practice ... One doesn't like being associated with some Mickey mouse design ... there is a lot of pride in engineers, particularly here ... The Italians are renowned for their pure design philosophy, unity of form and function, singularity of purpose ... it gives their products charisma, it sells ... But it is difficult to maintain designs which are at one with your instinct, whilst at the same time, having to meet a number of external constraints such as law, cost, levels of skill needed, etc. ... Any system which involves people interaction requires knowledge of motivation, understanding politics ... because in business every system is by definition a compromise ... somewhere along the line (Chief Design Engineer, Heavy Electrical Engineering Company, Scotland).

There are a number of assumptions and arguments here. The engineer clearly has an idea of what constitutes 'purity of form and function' but offers only a glimpse of what that may be, i.e. something that is not 'tacky', 'too pinickity', or 'compromised'. He goes on to argue that the Italians, amongst others, are renowned for their 'pure design philosophy', which gives their products 'charisma'- but, again, he does not really specify what this philosophy looks like, other than that it is a type of design, that is 'at one with your instinct' and that this instinct gets compromised on 'the altar of cost benefit analysis'.

This argument was reiterated by a variety of engineers, at different levels, from recently chartered engineers, through to chief design engineers and in a variety of manufacturing settings. It is worth exploring in some detail just what it is these engineers are trying to elucidate. Take, for example, the following comments from a Professor of Engineering and Director of an Artificial Intelligence Centre, a Senior Design Engineer in the Pharmaceutical Industry and a Design Engineer in the Aviation Industry:

> There is a certain understanding, in my opinion, amongst engineers, as to what constitutes a good design - it's something you instantly recognise ... It's where the form of the design naturally follows its function ... It's where there is a sense of purpose and unity about the whole thing ... Take the C5 from Sinclair. That is what engineers would call a nightmare [and] it offends every engineering instinct ... It doesn't meet its purpose and is tacky ... It is too low, too under powered, too uncomfortable, too expensive and too dangerous ... (Professor. of Engineering and Director, Artificial Intelligence Centre, Scotland).

> The simpler you can make it the better. The less parts the better. The less moving parts even better still. Hindsight has 20/20 vision ... If someone places a design in front of me, I can recognise more or less straight away if this is a good or bad design ... (Senior Design Engineer, Pharmaceutical Manufacturer, Scotland).

> What I understand by purity of design, is that the product is neither over-engineered, nor under-engineered but just right ... Sometimes we under-engineer products, that is we could have built them better, made them more suitable for the purpose ... But we've been working to budget ... Other times I have to admit we have over-engineered products [and] they have been too complicated for users to operate, overly elaborate and sophisticated for the purpose to which they were used ... Money comes into it ... There was a time when we had virtually unlimited finance and round here there were all kinds of whacky projects underway ... Real technological overkill ... (Design Engineer, Aerospace Industry, England).

The notion that an engineer can almost instinctively spot a well engineered design comes over very forcefully. We are not, however, really offered an explanation of how or why. Is it that a well engineered product is really the one that is simple and has the least number of moving parts? What criterion do you use to denote notions of simplicity? Or how do you know when you have too many moving parts? The following interviewee offers a partial response to these questions:

> We are taught ... and I think it's common sense that you don't waste energy ... You keep frictional losses down, mechanical tolerances close ... Take the internal combustion engine ... If you design in counterbalancers to offset vibration caused by, let's say, a vertical twin engine, these counterbalancers soak up power creating frictional losses ... So why not just build a triple or four cylinder engine, or utilise two stroke rather than four stroke? ... With two power strokes rather than one power stroke in every four you can then use less cylinders and still maintain smoothness (Mechanical Engineer, Heavy Electrical Engineering Company, Scotland).

SL: Yes, you will get smoothness but that is only one characteristic. What of economy, mechanical longevity and emission? Doesn't the four stroke currently fare better here?

> Yes, smooth running is only part of the equation but that's my whole point ... We have this body of theoretical knowledge which says: okay, from a purely dynamical point of view, this is the best way to cut down frictional losses ... Utilising calculus like the coefficient of friction, we can calculate a variety of frictional scenarios ... But then, yes, there is the reality that the internal combustion engine has its many uses and different users want different characteristics ... so it becomes a compromise (Mechanical Engineer, Heavy Electrical Engineering Company, Scotland).

If all design is thus a compromise, why do engineers appear to accept readily that there is such a thing as purity of design? This particular engineer seeks to locate answers to this question in terms of a body of theoretical knowledge, encompassing thermodynamics and frictional equations and to document how, from a 'dynamical' point of view, you can arrive at the notion of 'design purity'. The argument, however, would be more convincing if such designs occurred in practice. However, virtually all of the engineers I interviewed stated that design was a compromise, so how can these same engineers still assert the validity of the concept? It is interesting to note some of the examples of design purity offered by my interviewees:

> Take the Italian car and motorcycle manufacturers ... Here we see an unabashed single-mindedness of purpose ... You take a car like the Ferrari, or a motorcycle like the Ducati and take it to pieces [and] it just smacks of quality and purpose ... Virtually every part is functional in form ... whilst also being engineered to the highest standards ... There are no hidden gimmicks ... Contrast this with the Japanese, who over-engineer everything ... Look at the latest Toyota Supra ... They couldn't get the geometry right ... because the car is a compromise ... It's not a real sports car ... so they had to add on a package full of electronic gadgetry to balance out the steering and handling ... That's what I call over-engineering (Design Engineer, Chemical Company, Scotland).

When I pointed out to this engineer that for many people the Ferrari had a number of drawbacks - for example, price, lack of economy, incapacity to carry more than two people, lack of comfort, width and dangerously low ride height - he recognised this and argued that: 'because of the design's uncompromising nature ... it is so pure [and] it demands respect'. If this engineer was alone in making the analogy between Ferraris and pure design, his argument could more readily be dismissed as personal prejudice; but he was not:

> A concept like the Ferrari and much of the best Italian and German engineering is uncompromising ... single minded and demands respect ... from both an engineering point of view and from the driver's point of view (Senior Production Engineer, Heavy Electrical Engineering Company, Scotland).

The fact that many engineers recognise that the Ferrari is not everyone's ideal, or that it has real drawbacks, is irrelevant to them. Indeed, more than this, it seems to constitute almost a necessary qualification for the car having such 'purist' engineering status. It is almost as if the very singularity of its purpose and the fact that it is so uncompromising, compels the human being to either adapt to the singularity of its design or reject it. The same engineer argued that:

> This design reflects to me a kind of sado-masochistic philosophy amongst Ferrari engineers ... Let's face it, they design this bloody outrageous car with so much power and which is so outrageously fast for today's road, that it's a potential weapon and then they turn round and say, "Well only a privileged few can drive one and when they do, they will have to suffer the consequences, in terms of its demanding driving characteristics and uncompromising nature." ... Only a sado-masochist would do that ... but you've got to respect them for it (Senior Production Engineer, Heavy electrical engineering company, Scotland).

It would be easy to dismiss the debate on design purity as just a reflection of a dominant, white, male, macho culture centred within specific engineering fields, say, motor manufacture and the military; Cockburn (1985) alludes to this. But such an argument is too sweeping because engineers, in a variety of fields, utilise this concept. Take the following example from a design engineer, in the Pharmaceutical Industry, talking about the design of a pair of surgical scissors:

> I spent several weeks designing these scissors ... Just hold them ... You can feel the balance ... It's perfect ... These are not your high street junk ... This is pure engineering ... I've had doctors and nurses contacting me congratulating me on the design ... They like the feel, the balance but also the look ... Have you seen such a beautifully balanced pair of scissors? (Design Engineer, Pharmaceutical Industry, Scotland).

Or again a materials engineer talking of the design of drill bits:

> People often fail to appreciate the work [and] the design that goes into the making of one of these ... This drill will cut continuously for longer than any comparable drill on the market ... It's as tough as a diamond ... I made no compromise in it's design, it's pure engineering (Design Engineer, Machine Tool Industry, Scotland).

Both engineers were moved by the products they had designed, and felt a strong sense of pride and self-worth from designing 'pure', well engineered products. Neither, however, could accurately pin-point or describe what 'design purity' was, or how they came to be able to distinguish between 'pure', well engineered, products and poorly engineered products. I would argue tentatively that notions of design purity are learned, they are socially informed, rooted in specific socio-cultural conjunctures but not mechanistically derived from them[24]. A number of interviewees alluded to how notions of design purity may be learned:

> In the past, through the craft route, you would be apprenticed, you would serve your time ... practical hands on time with engineers, fitters, draughtsmen ... More than this ... it's difficult to place ... You kind of picked up a feeling for the discipline [and] learned a kind of purity of design through practice ... [You]watched materials fail under different conditions [and] picked up a repertoire of materials and stresses, a logicality of design ... The learning curve went beyond the technology [and] you gauged a feeling of the formal and informal politics of design (Chief Design Engineer, Heavy Electrical Equipment Manufacturer, Scotland).

> [It's] seeing designs unfold ... Some fail, some succeed ... [And then] knowing why [and] learning the theoretical knowledge of materials in college ... Slowly you build up a picture of what is good and bad engineering ... I remember as a rookie, designing a crankshaft for a fixed pump ... it was bomb proof - needle roller bearings supporting each section of the crank and an oil pump that pumped at tremendous pressure ... I remember the senior engineer turning round to me and saying, "No good. ... over-engineered ... It's a fixed pump you are designing for a quarry, not a bloody Rolls Royce ... Our customers won't pay for this and we don't want to sell them something that's going to last forever!" ... That was my first awakening (Design Engineer, Heavy Electrical Equipment Manufacturer, Scotland).

What these examples illustrate is that notions of design purity and good engineering are socially rooted: both of these engineers refer to the social relations of production which condition their understanding of design purity. Thus the latter engineer developed what he considered to be a well engineered product but had to reassess notions of what constitutes 'well engineered' in the light of 'commercial' criterion. There is obviously an intimate link between notions of 'under-engineered' and 'over-engineered', and the size of one's budget and nature of the market - this linkage is most obvious in the case of the aviation engineer quoted earlier highlighting the 'whacky' projects being undertaken in his particular firm due to an almost unlimited research budget, leading to the production of 'technological overkill'. Noble's (1985) study of CNC machine tools documents a similar process whereby relatively unlimited budgets in the military sector led to the development of overly elaborate, very sophisticated and costly forms of CNC machining.

Notions of what constitutes design purity are also linked to particular aesthetic and cultural practices. These in turn can be related, though not mechanically, to changes in the development of the forces of production. For example, much of the hand crafted products of the late 18th and early 19th century may be seen today as overly intricate and delicate, what one engineer described to me as 'too fussy'.[25] With the development of the manufacturing process and particularly mass production for mass markets, such detailed intricate labour is marginalised and is replaced with designs of less detail, less intricacy and smoother lines. This reflects changes in production methods, technology, quantities of labour time and the rise of cheaper synthetic materials. These, in turn, can be seen as an indication of the rise in the organic composition of capital, the capitalisation and standardisation of manufacture, and the need to increase labour productivity and reduce materials costs, so as to maintain profitability. In short, changes in aesthetics and culture are shaped in part by changes in the mode of manufacture and, once established, have an impact on that manufacturing process. Engineering notions of design purity are formed in this crucible of continual change but interestingly, have a degree of stability and consistency which appears almost impermeable to change. Whilst different examples of what constitutes 'design purity' can be found in different branches of production and at different historical conjunctures, the notion that there is a 'design purity' seems to transcend specific socio-cultural conjunctures and modes of production. For example, engineers I interviewed in Poland also maintained that there is such a thing as 'design purity' and alluded to it in similar fashion - functionality of purpose, unity of form and function, etc[24].

Notions of 'design purity' serve to depoliticise and depersonalise design. They are used by engineers to refer to what constitutes a good, as opposed to bad, design. They are used as a term of reference to establish an engineer's estimation of self-worth and pride, and to differentiate engineering from other occupations, i.e. mechanics, technicians, but particularly, non-productive managers who, presumably, would not know a 'pure' design if they tripped over one. They also serve as ideological props, enhancing engineering mastery over nature but also over mere humanity which should stand in awe, if not fear, of some of its most 'pure' designs. Design purity is a concept that is esoteric and elusive; none of the engineers I interviewed could pin it down with any precision. At best, they could only allude to the social processes of its production - particularly craft practices, training, forged acquaintances, specific bodies of theoretical knowledge, etc. Ironically, it may act to reinforce relations between skilled workers and many engineers who may share similar productivist attributes and values regarding the relevance and importance of technology in society. It may also reinforce the way in which that technology, and with it, the social relations and emotions surrounding its design, get compromised on the altar of cost-benefit analysis and through the impersonal workings of the market.

What is of interest, is how the concept may affect the design process and engineers' estimation of that process. Take, for example, the following comment from a software engineer in his late twenties:

> I see a process taking place within all fields of manufacture towards standardisation and new logicality of design ... Look at clothing ... What characterises the top designer labels? ... The elegance of the cut ... the purity of the design. The same in cars [or] building construction ... It's the end of detailed work and unnecessary fussiness ... Design, like production, should be simple, straight cut, logical and uncompromising [and] that's how I want to design my software (Software Engineer, University, Scotland).

Forgetting for the moment whether this particular designer has been incorporated into the post-modernist aesthetic, the implications of such a design philosophy on, for example, job enrichment and reskilling is alarming. Would the designer prefer, on the basis of not wanting fussiness or compromise, to develop software with minimal human override or which sought to impose its 'logical' uncompromising structure on the human condition?

In summary, notions of 'design purity' may act to reinforce engineers' perceptions of their rightful role within the design process as the 'guardians' of technology and progress. More importantly the concept serves to establish engineers' own identity *vis-à-vis* shop floor but particularly management employees. There is also a sense in which the concept 'pure' engineering represents an idolatry of engineers own labour as uncompromising, practical and purposeful activity. Notions of 'design purity' also serve as a basis from which engineers not only judge the value of the final product of their own labour but, importantly, make value judgements on others labour within the overall process of production. Notions of 'purity' serve engineers rather like the vestal virgins serve Christianity: they embody notions of chastity, devotion and denial and act to remind us of our fallibility and weakness - our compromised human condition.

Technological Determinism

Much of the literature and practice of engineering is couched in a technologically deterministic vocabulary that abstracts engineering practice and artefacts from the social relations of production. Histories of technologies become histories of great names and the unfolding of some abstract law of progress. Latour argues:

> Despite the fact that it is hard to picture diesel engines, or bicycles, or atomic plants, reproducing themselves through mating, trajectories are drawn that look like lineage's and genealogies of purely technical descent. The ... conceptual history of science or epistemology; these are the names of the discipline that often should be X rated that explains the obscure reproduction habits of these pure breeds (1987: 133-34).

For the resolute technological determinist, technological forces are the decisive factors generating social change. From this perspective, the process of industrialisation is abstracted from the social relations through which design and production takes place. Technological artefacts, such as textile machinery, steam technology, navigational technology, or electrical and mechanical power, are seen as causing social change; and, in strong versions of technological determinism, as the main determinants of that change.

Noble argues:

> Because of its very concreteness, people tend to confront technology as an irreducible brute fact, a given, a first cause, rather than as hardened history, frozen fragments of human and social endeavour (1984: 8).

This is reinforced by the fact that the social relations of exploitation under capitalism *appear as natural* technical relations of administration. Likewise, the rise in the social organic composition of capital and the resultant dominance of dead labour over living within many manufacturing processes reinforce technologically deterministic views among engineers. The rise in the organic composition of capital tends to obliterate labour power as the source of value, as profit is mediated via the socially necessary labour time that it takes to produce commodities. Advanced stages of mechanisation, automation and robotisation seem to confirm that it is technology which is the source of value and cause of change. Technological determinism thus places engineers, historically, centre stage and reinforces their perceptions of specific manufacturing processes and of particular technologies as natural, neutral and inevitable. This view masks the particular choices and the consequences of an engineer's work on, for example, the sexual division of labour, skills or quality of working life under a technicist discourse. Consequently, the processes whereby specific divisions of labour, skills and forms of work are engineered remain hidden, reducible merely to technical imperatives, read off from specific technologies:

> In utilising these automatic packers ... machine sensors and bar code scanners there is less need for labour and supervisory staff ... If we had a different technological configuration, we would have different labour requirements ... Sad but true (Mechanical Engineer, Automotive Components Manufacturer, Wales).

To this engineer at least, the social division of labour is a function of the forms of technology. However, this analysis fails to consider the politics of the design remit which led to the installation of this, rather than other technologies. As the production manager within the same company put it:

> We considered a variety of strategies for boosting our competitive position ... including buy-outs, advertising, sales drives and implementing new quality control and productivity related bonus schemes ... In the end, it was a political decision ... The technology merely carried through the political aim. I'm not stupid. I know the debates on computer versus human centred systems ... In this climate we opted for computer control ... Really, I think some of the engineers here just think we are impressed by the technology. I doubt they realise their proposed solutions were part of our overall strategy and accepted for no other reason (Production Manager, Automotive Components Manufacturer, Wales).

Likewise, technological determinism can act to conceal sexist bias within the design process:

> Work in this factory is very delicate: soldering of circuits, routing of wires, handling of small fragile components ... This type of work is best suited to the

> girls, that's why we employ so many of them in production (Electrical Engineer, Electronics Manufacturer, Wales).

What the above engineer fails to mention is that 60% of these girls were YTS placements, or part-timers, working, as one manager said, for less pay than a man would be prepared to take. Also:

> This kind of work - light assembly - is regarded round here as traditional women's work ... If we put a man on the job he would soon start complaining and showing an attitude (Production Manager, Electronics Manufacturer, Wales).

The huge armies of technical staff thrown into being by the development and extension of capitalist relations of production, further reinforces technologically deterministic attitudes, within engineers, by isolating individual engineers from the total process of design and, in consequence, inhibiting their comprehension of the relationship of detailed work to the total work:

> I spent several years working on the design of a machine for grading components on a flow line, essentially lifting them off the line according to grade and type and feeding them into other lines. This was part of a research programme that myself and colleagues had been involved in, along with teams from other interested companies and vendors of hardware and software, to achieve the automated factory ... Only last month did I finally get to see my work in operation ... It actually depressed me, all that money, all those years of research to produce this design and you could have took a YTS trainee off the dole put him on the job and got exactly the same result with a saving of millions of pounds to society ... What really bothers me is that I never even contemplated this alternative. Like all my colleagues, we were just geared up into the project trying to advance the technology for technology's sake (Design Engineer, US Electronics Company, Scotland).

Rosenbrock (1987) cites the example of a lamp factory in which the industrial engineer chose to use middle-aged women to do one particular task, placing a filament in a light bulb every 4.5 seconds, because it would have offended an engineer's sense of design to waste a robot on such a low level mundane task. Rosenbrock's argument is that the designer thought nothing of wasting the human being's potential.

Interestingly, the latter example was in Hungary, whereas the former example is a leading US electronics company in an advanced capitalist economy. What can we deduce from these two cases? Obviously both engineers felt a robot was wasted, in both cases because it was too engineered and too sophisticated for such a simple task. The only significant difference is that in the former case a robot was used (despite offending its designer's sense of purpose), whereas, in the latter case, a robot was not used because it was cheaper and more convenient to use a middle-aged woman. We can straight away conclude it would also have been cheaper to use a YTS trainee or middle-aged woman in the former case.

So why did a robot get used in the capitalist context? Does the answer have something to do with capital's attempt to control and subordinate labour within the production process? This hardly seems realistic. A YTS trainee, or a middle-aged woman, on a production line, surely can not pose that much of a control problem to management in the context of recession and labour movement retreat; capital has managed far more recalcitrant sections of the labour force quite successfully and at far more militant periods of history. Anyway there are a variety of control strategies and managerial repertoires that could have been considered. Maybe management was taking advantage of the historical conjuncture of labour retreat and high unemployment to drive through new manufacturing processes and to impose new divisions of labour. In this particular case, it hardly seems worth the company's effort to spend millions on designing a robot solution when managers within the company were making it quite clear that recessionary conditions meant that such investment would possibly not recoup itself. Was a robot used because the mutual interaction of competition in this particular branch of production necessitated high rates of productivity to survive? I will let the engineer speak for himself as he answers the point succinctly:

> There is no economic benefit, at least as far as I can see it from utilising this robot, it can operate no faster than an average worker. In fact it is probably slightly slower. True it won't tire and make mistakes so easily ... but Christ, several million pounds of mistakes - that's what it cost to develop! ... I think the reason why it got developed has to do with the nature of the interest groups surrounding this project, both here, in the parent company, components and software suppliers and our customers' design departments ... What did management request? Broadly, flexible manufacturing capability. What did we deliver? Flexible manufacturing capability - but in what form? ... Software, machinery and robotics ... Almost instinctively their and our designers along with suppliers dived into technological solutions ... We all communicated in the same language and we didn't have a different vocabulary ... We didn't even consider a different vocabulary (Design Engineer, US Electronics Company Scotland).

What this engineer is describing is the social relations and actors involved in the design who had vested interests in certain solutions. The customers wanted flexibility and the suppliers and designers were both keyed into particular interpretations of flexibility. In effect similar cultures were talking to and working in collaboration with each other - engineers and technologists, all speaking the same vocabulary of automation. In other words, there was a technological matrix surrounding the design. Management merely specified the broad context of manufacturing flexibility; engineers and technologists engaged in the project then pushed through a particular interpretation of flexibility.

The former example indicates the grip which technological solutions to manufacturing problems has on the minds of technologists in capitalist societies. It does not, however, explain how that philosophy gets into mainstream technological vocabulary and technologists' ways of thinking. This is a complex question. On the one hand, one can argue that the early history of invention was intimately tied into the development of manufacturers' struggle to secure control and maintain order over the workforce. Many of the early inventors were directly recruited from the bourgeoisie, often businessmen in their own right, with no sentimental predisposition towards labourers. Maybe engineers' early development and their emergent and relatively privileged place in the division of labour, as designers of technologies and machinery which controlled labour, mitigated against their 'humanisation' as a social group or foreclosed alternative design paradigms that would have antagonised employers. Maybe engineers' own struggles to attain recognition from employers and managers meant taking on board, developing and modifying dominant managerial views of organisation and control of labour processes. Perhaps the ending of craft routes into engineering ruptured the chord connecting engineering theory to practice, removing engineers from the shop floor, further isolating them from production workers and making them more susceptible to technologically determinist views.

Rosenbrock argues that:

> Engineers in my experience are never taught a set of rules or attitudes which would lead to this kind of view [to disregard for full use of human abilities]. Nor do they base their actions on a set of explicit principles incorporating it. Instead, we have to imagine something like the 'paradigm' discussed by Thomas Khun. This is the name he gives, in the sciences, to the matrix of shared attitudes and assumptions and beliefs within a profession. The paradigm is transmitted from one generation to another, not by explicit teaching but by shared problem solving ... We still have to ask how this paradigm arose (1987: 282).

My own research indicates that engineers *do* get taught a set of rules and attitudes that makes them amenable to particular design interpretations.[26] Rosenbrock too readily dismisses the impact of this education and downplays the prevalence of certain values and principles within engineering, e.g. control and system theory which may reinforce technologically determinist views within the design process. Rosenbrock's explanation of how this technologically determinist paradigm is formed is instructive. Essentially, he argues that we can distinguish between two types of machinery: that which enhances human ingenuity and skill and that which destroys it.

> For reasons which were valid enough in the early nineteenth century and which are well documented by Ure and Babbage, the second course proved more profitable for the inventor and the manufacturer than the first. When the engineering profession arose later in the century it, therefore, inherited only one attitude to the relation between machines and human skill, which is essentially the one described above (1987: 284).

Unfortunately, he does not advance on this. Why did the second course of action prove more profitable than the first? How did this attitude to design get generalised? Why did engineers accept it? Did all engineers accept it? Are engineers merely the passive recipients of a dominant culture moulded exclusively by the manufacturers and industrialists of the day as Rosenbrock seems to suggest? This argument leaves too much unexplored and unexplained and portrays engineers in a static, wooden, relationship to manufacturing and to the design process. If we want to understand more about why certain engineers hold technologically deterministic positions, we need to look further. A useful focus for this is to consider the issue of compromise within the design process:

> At school and college we were taught history as a history of great names and inventions ... Progress seemed to be the inevitable outcome of these inventions and anyone who stood in the way of their development was a Luddite ... I think in this kind of presentation we have a view ... which undermines engineers' attempts to get to grips with the actual process of design ... The nearest we get to recognising the messiness of design is when we talk about engineering as a compromise ... But what do we mean? A compromise of what and between who? (Production Engineer, Automotive Components Manufacturer, Wales.)

Any serious investigations of compromise would challenge dominant views of technology as rational, given and incontestable and would force engineers to consider their role in the design process more critically[24].

Summary

McLoughlin and Clark (1994) highlight the need for research into what they refer to as the 'architecture' of the engineers' 'black box'. In many ways this is precisely what I have done. I have opened up the 'black box' of technology to show how specific engineering values, methods and practice constitute, in the words of Clark *et al* (1988), an 'engineering system'. The purpose behind disclosing some of the elements of this system is to demonstrate how it conditions the process of design and engineers relationships to others in the design process.

Rather than arguing that some notion of capital expediency infuses the psyche and work of engineers, turning them into direct agents of capital within the process of business restructuring, I have highlighted the diversity of values and methods engineers are exposed to and, indeed, which they consciously generate. These values and methods give identity and purpose to engineers' work and to the products of their labour. Whilst some of these values and methods act to reinforce the subjugation of labour within the process of production others act as sites of possible unity with that labour.

The important point to stress is that engineers are not just the passive recipients of a dominant ideology. Transformations within the capitalist mode of production, leading to the historic growth in the organic composition of capital and the dominance of dead labour over living within the production process have placed engineers and designers, broadly defined, centre stage in the process of manufacture; but engineers` own experience of this process and its contradictory developments - for example, in terms of the combined and uneven development of the productive forces, crisis and rationalisations - is such that a variety of sites emerge for the growth of distinctive cultures and interpretations of change.

These values and methods also serve to legitimate a particular relationship between designers and the design process - for example, establishing engineers as professionals possessing distinct knowledge and principles which help to define engineers relationship to management and workers. Many of these values, principles and methods are utilised heavily by systems analysts and information technology professionals generally. One cannot, therefore, adequately understand the work of systems analysts without understanding this shared 'tool kit' of values and methods. In the following chapters on systems analysts and the software bottleneck I discuss these values and methods more fully and focus upon the ways in which systems analysts use and modify them in their own practice of design.

Systems Analysts Work, Values, Methods and Role in The Design Process

Introduction

In many ways engineers are a heterogeneous group, located within distinct disciplines of engineering for example, mechanical, electrical or production engineers and spread across a variety of industries and sectors. This generates complex cultures and diverse work activities and experience which mitigate against defining engineers as a specific group of workers with a specific relationship to the labour process. In contrast, systems analysts are a more homogeneous group of workers, generally implicated in designing technologies of rationalisation - where much of their work deals with the very substance of control, cost cutting, accounting and surveillance (Ryan 1989).

The onset of recession in the late 1970s stimulated investment in information technology which enabled firms to both rationalise and streamline non-profitable activities like administration, surveillance and accounting whilst at the same time securing tighter control over labour and raising its rate of exploitation (Thompson 1995, Ryan 1989, Sturdy 1992, Button 1992). Systems analysts are deeply implicated in the process of business restructuring and are perceived by many users, at a variety of levels, with some trepidation and awe. This is not simply because they are at the forefront of a new technology but because they are at the forefront of a process of restructuring which leads to job loss, rationalisation and disruption. Systems analysts are often perceived by users, engineers and even themselves as the archetypal 'yuppies'. Like any caricature, this is a generalisation, but it is nonetheless one which has an element of truth within it. I was immediately struck by the different cultures, lifestyles, dress and outlook of systems analysts compared to engineers. This contrast is brought home, for example, in debates within the systems profession over whether or not systems analysis is an engineering discipline or an art. On the one hand systems analysts utilise many of the concepts and vernacular of engineering; but, on the other, they also wish to distance themselves from that culture, stressing the interpersonal, artistic and 'business driven' nature of their work and their incorporation into the dominant business ethic.

In this chapter I discuss what systems analysis and design is, who systems analysts are and whether systems analysis and design is engineering or art. I also discuss recruitment paths into systems analysis, the skills required, issues of deskilling, and systems analysts' values and autonomy within the design process. Finally, I explore issues of professionalism and status and the way these influence systems analysts' work[1]. The objective is not only to provide insight into this group of workers but also to highlight the ways in which systems analysts explain their designs and justify their work within the broader process of business restructuring discussed-above, in Chapter 1[2].

Systems Analysis and Systems Analysts

The British Computer Society (1988) argues that the need for systems analysis stems from the rapid growth in information technology and its increasing centrality to industry, business, commerce and government.

> In the forefront are the systems analysts and designers who are critical to the effective use of information technology. Their technical knowledge and business understanding enables them to play a key role in matching the application of information technology to the ever changing needs of business and administration (BCS 1988: 1).

Changed terms of competition and recessionary conditions have stimulated the development and utilisation of information technologies within business and organisations, predominantly as a rationalising technology (Braverman 1974, Noble 1977, Kraft 1979), and have likewise generated large demand for computer systems analysts. However, computer-based systems analysis, as a distinct occupation, can trace its roots back to the Semi-Automatic Ground Environment (SAGE) project sponsored by the US Airforce during the Korean war (to centralise the North American radar system). It was at this time that the term 'systems analyst' emerged, to denote the separation of the conceptual task of writing a programme from the mechanical task of writing the code (Kraft 1979: 7).

At a more general level, systems analysis can trace its origins to two overlapping traditions: firstly, unsurprisingly, it is rooted in the systems movement, discussed in the previous chapter, with its concern with the structuring of problems and identification and ordering of the various components within a system. Secondly, it is rooted in control engineering which, according to Vickers (1986), became the new discipline and philosophy which permeated the work of engineers and technologists from the 1930s onwards. One of my interviewees candidly discussed the implications of these two roots of systems analysis:

> Systems analysis at a very general level is concerned with producing change within any given system.....one analyses a given system with a view to changing it....but the degree of change is proscribed by shall we say a mental set of what is practicable and possible.......Control and systems theory offer models of organisation that are comfortable....I would suggest for most analysts because they are not radical models. They are not models which readily recognise contradiction or antagonism but models which imply solvability....as systems analysis matured from its unstructured roots in programming systems and control theory got heavily utilised...possibly because disputes over parameters and boundary problems are comfortably left to others (Senior Lecturer and Consultant Software Engineer, University, Scotland).

A BCS document charts the nature of the occupational group:

> In the past, it was mainly computer specialists who used systems analysis to help them understand business systems and to make improvements in them - such people may be called computer systems analysts. Today an increasing number of non-computer specialists are using systems analysis to enable them to participate effectively in the development and implementation of efficient business systems - such people may be called business systems analysts. Both types of systems analyst employ the same methodology; they can be trained together; they often work together, each bringing his or her own experience to bear on the co-operative task of developing a new system (1988: 2).

The BCS argues that systems analysis is:

> a methodology used world-wide for creating efficient information systems, the methodology prescribes

the work to be done
its sequence
the tools and techniques to be used
the management of systems development
investment appraisal
quality assurance
the documentation to be produced (1988:2)

The methodology is supposed to guide analysts through the various stages of the analysis and design process. The typical stages in analysis and design are shown in the figure below.

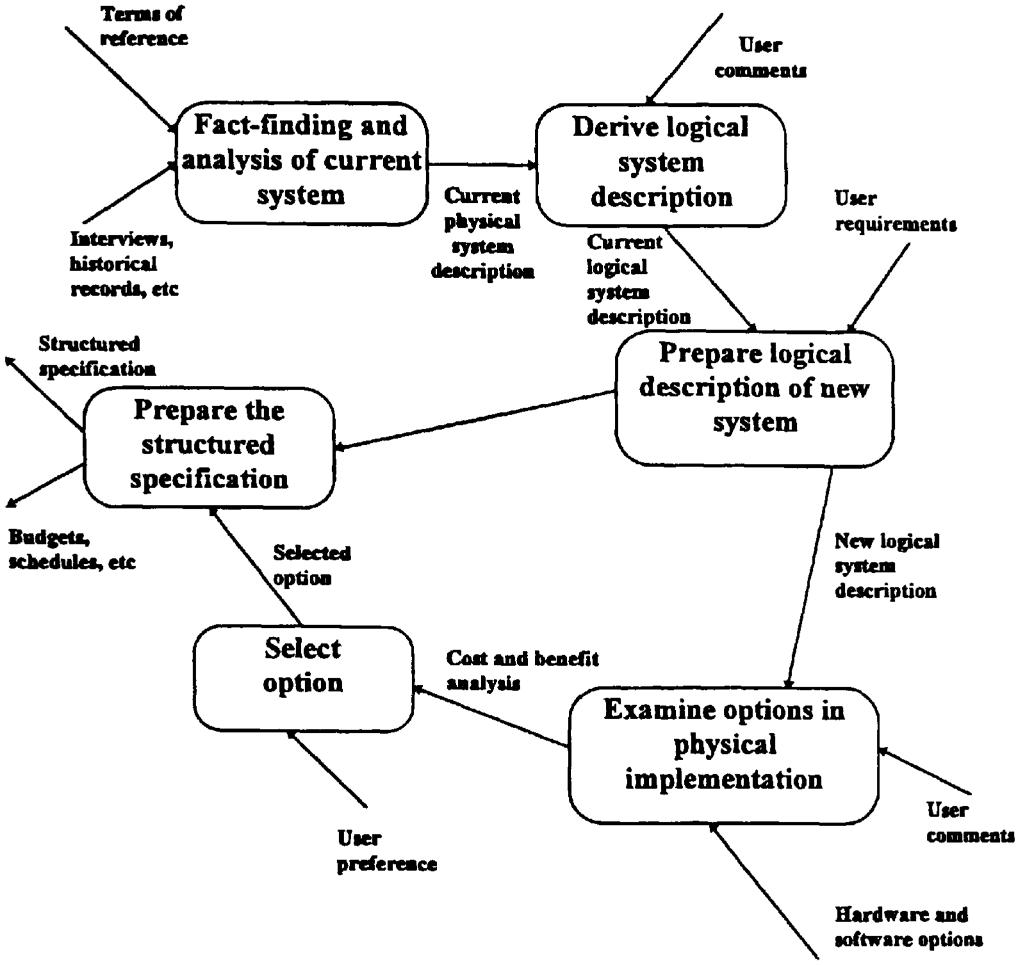


Figure 3. Stages in Analysis and Design

The BCS defines systems analysis in terms of the application of a given methodology and denotes two types of people who use this methodology: computer systems analysts and business systems analysts.

There are a number of problems with this formulation Firstly, there are a multiplicity of competing analysis and design methodologies which indicates that there is no sure agreement as to which is best. Secondly, and more importantly, my research indicates that many systems analysts and systems managers simply do not use any formal methodology even though they are familiar with them:

> I've designed some of my best systems on the back of a fag packet (Systems Manager, Automotive Components Manufacturer, Wales).
>
> Good analysis and design comes through brainstorming sessions with users ... methodologies are okay for the nervous types or inexperienced ... then again they shouldn't be in systems in the first place (Systems Developer, Water Authority, Wales).
>
> We can all play the rules game ... we can all recite rules or best practice in analysis and design ... structured methods are supposed to epitomise good practice ... in theory maybe they do ... but, in reality, this wonderful theory falls apart in the hands of the inexperienced analyst (Systems Analyst, Large Public Service Institution, Derbyshire).
>
> Systems analysis is intuitive ... but not all people have got intuition ... I would suggest they rely heavily on methods to compensate ... (Systems Analyst, Electronics Defence Sector, Scotland).

Those systems analysts I interviewed and observed utilised a variety of techniques such as data flow diagrams, data dictionaries, entity models and cost benefit analysis, etc., but they did not theorise their use of these techniques in terms of BCS definitions of an agreed and accepted systems analysis methodology. Rather, they utilised these techniques as a mechanic might utilise a spanner, as a tool. The majority of analysts I interviewed argued that the actual knowledge needed to carry out analysis and design was far more esoteric:

> ... it's a personal experience ... it's about politics and persuasion ... it is in my opinion an art ... don't get me wrong, you can do analysis via a proprietary methodology but it would be like trying to cross the road reading a manual,

> whilst your eyes are down on the print a car has run you over (Systems Manager, Heavy Electrical Equipment Manufacturer, Scotland).

Most analysts explained their work in a technical vocabulary which downplayed political decision taking and presented analysis and design in terms of a technically rational processes. However, the above interpretation finds support in the work of Feeny and Sladek (1977) who address the different roles performed by a systems analyst. They conclude that the success of the analyst's performance depends on their ability to play the correct role, with the right people, at the right time; a systems analyst may well have to assume `the role of persuader, catalyst, confronter or impostor, in order to bring about change and this needs a high degree of political skill' (1977: 85-86).

The BCS definition of systems analysts is too restrictive in that it downplays both the diversity of people doing analysis and the factors contributing to this diversity. My own research indicates that definitions of systems analysts are far from clear cut:

> We don't call ourselves systems analysts but systems engineers. You should be careful in your survey about what you mean by the term systems analyst. In a data processing environment, the function of a systems analyst is standard and simple, but another animal is evolving called a systems engineer. These people have got to be able to deal with all the vagaries of industrial life. Systems engineering, when it comes down to the nuts and bolts, is the application of formal and informal politics of industrial organisation (Managing Director, Software and Robotics company, Wales).

> There are no systems analysts at CMWS. That is not to say we don't do systems analysis, rather systems analysis is only one part of the work we do ... we are not just looking at the analysis of the system, but also looking at the commercial considerations - market pressures, geography, etc. ... that's why we call ourselves consultants (Director, Micro Computing Centre, Wales).

> Systems analysis is a stage people go through as part of a career progression, but I'd suggest they wouldn't like to be called systems analysts, I expect they'd prefer the title 'systems engineer' (Consultant, Multi-national Hardware/Software Manufacturer, London).

In conditions characterised by chronic labour market shortages of IT staff, in general, (Vowler 1989) and systems analysts in particular (Butcher 1984) and in a rapidly changing technological and market context, neat bipolar categorisations, like those of the BCS, concerning who does and who does not perform systems analysis, are increasingly seen as dated by actual systems practitioners:

> In this department, I have some 40 systems staff, we all, even the youngsters do systems analysis - sometimes as part of our job, but as the changed title suggests, we are systems developers and analysis is only one aspect of development - I regard my staff as supermen, a new breed of computer experts with all rounded skills, from programming through to analysis ... I pay them accordingly ... the work's hard but the market demands we become more flexible and drop rigid job divisions ... that are, anyway, becoming a thing of the past ... part of the old DP ivory tower of systems development that characterised much of the sixties and seventies nightmare (IT Director, Major High Street Bank, London).

The argument that divisions of labour, within systems development, are changing and new job titles emerging to reflect this, would seem to be confirmed by the NCC (1985) Skills Survey Report which indicated that over half of its respondents had dropped traditional analyst/programmer distinctions and were adopting more 'fluid' labour policies *vis-à-vis* computer professionals, including the increase of multiskilled labour with enlarged job functions, experience and training. This prompts Friedman to argue that:

> Overall, the structure of job categories in information systems departments is coming to look like research, or professional units within organisations, rather than the mass production departments predicted by Kraft. The base of the internal job pyramid is getting narrower, the upper middle layers wider (1989: 308).

Essentially, difficulties experienced in modelling increasingly complex and sophisticated user environments has resulted in the *ad hoc* development of a polyvalent division of labour, within systems departments. Strategies for dealing with user relations include user involvement in systems design, end user computing, information centres, decentralisation, prototyping, evolutionary systems development and changing the recruitment and skills sets of systems developers (Friedman 1989: 271).

Systems Analysis: Engineering or Art?

The BCS and IEE are attempting to establish systems development as an engineering discipline through advocating a tightening up of standards, tools, techniques and recruitment.[3] The emphasis within the BCS and IEE is on making software development an engineering exercise: systems engineering is emerging as a set of methods and tools applied, in a disciplined way, to the whole system design and development process, i.e. the entire systems life cycle (Beynon-Davies 1989). A typical system life cycle is shown below.

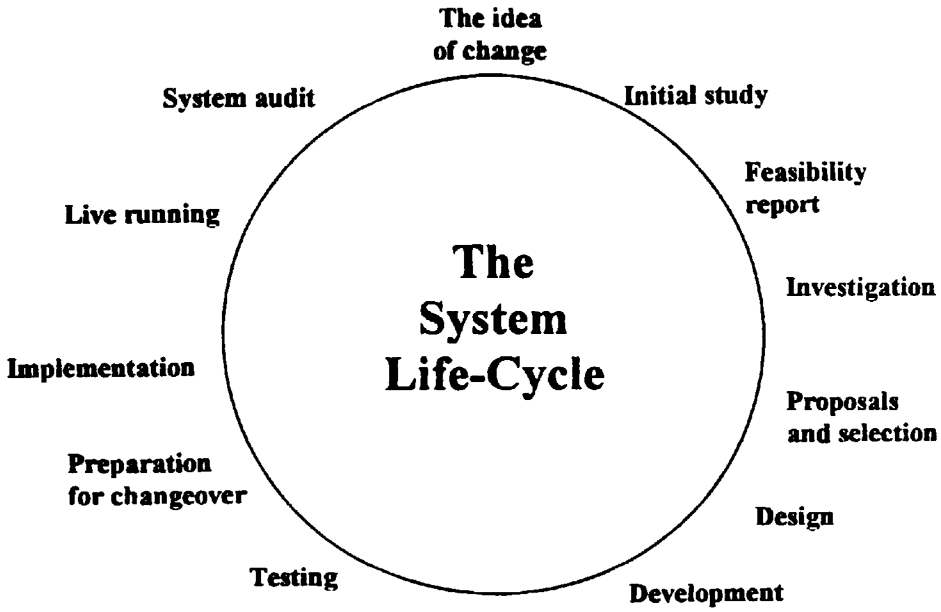


Figure 4. The Systems Life-Cycle.

However, BCS and IEE attempts to establish good analysis and design in terms of an engineering discipline was greeted with caution, alarm and sometimes resistance by many practitioners I interviewed:

> Software engineering and, indeed, the whole movement towards standards and utilisation of tools within the systems profession is on the one hand very laudable ... Martin's approach and the tools he recommends have their use ... But there is a tendency, particularly on the part of sellers of this stuff, to see it as the answer to all systems designs problems ... We have one of the best tool kits of any systems department in the country [and] we have graduates with heads full of the latest engineering approaches but I would swap them all for a couple of experienced business orientated analyst/programmers who can get out there and hold a good conversation with users (Systems Manager, Large Communications Company, Wales).
>
> This emphasis on software engineering worries me ... all stages of the systems development life cycle are not of equal importance. Ninety per cent of a good systems development is at the analysis phase: getting user requirements, understanding the issues, negotiating compromise. Most engineering tools are at

> the back end, even the use of structured methods like LSDM with detailed analysis requirement front ends, cannot alter the fact that systems development is primarily a political and not engineering process ... Not only are a repertoire of skills necessary, including common-sense and cunning ... but more importantly, a recognition that what you are dealing with is people in organisations, people with possibly different goals, pulling in different directions, with different worries ... no end of engineering tools can solve an essentially political problem (Systems Manager, Aerospace Industry, England).

> It is not more sophisticated tools, like CASE or 4GLs, etc. that we need. It's people who can communicate and who have experience ... A tool is just a tool ... Conversation, the ability to elicit information from users, the capacity to understand business requirements, organisational politics and culture ... and the broader political and economic forces operating on us all, is, above all, the most important criteria of being a good systems analyst ... I don't want wet behind the ears 'techies' from college in my systems department ... I'd prefer an arts student ... a sociologist or economist any bloody one but not a 'techie' ... (Systems Manager, Large Public Utility, Scotland).

The point being made is that it is business understanding and a broad based arts (not engineering) culture which is perceived by many analysts and systems managers as the key indicator of success; it is these which most accurately capture the work of the systems analyst. Indeed, several analysts were offended by suggestions that systems analysis could be standardised with appropriate tools and techniques:

> I've been in a senior analyst position for over ten years. Prior to that I worked up through the programmer/analyst route. Like most people in this department over the years I've developed a feel for the organisation and the nature of business. You spend more time listening and talking to users, becoming involved in broader systems issues, politics, etc.. Its a learning curve for which you are rewarded with project management and systems management posts ... Talk of systems analysis as engineering will reduce us in management's eyes to the status of engineers ... or techies ... In my opinion it's a retrogressive move on the part of the BCS and an understandable one on the part of the IEE ... but I and many colleagues do not like it ... The BCS are doing us no favours (Senior Analyst, Large Private Utility, Wales)

> Analysis is a political process requiring managerial skills ... It is not an engineering process ... The mentality which reduces it to such, is precisely the mentality that put engineers in their low status rut ... (Systems Analyst, Manufacturing Company, Scotland).

There is little doubt but that as one progresses up the systems career ladder, one is punished for being a 'techie' and rewarded for being business- orientated. As Murray (1989) argues, even those who entered the profession via the programming route become less wedded to notions of technical rationality and take on board more business and managerial philosophy as they climb the career ladder and increasing portions of their time are spent alongside users and managers. Too close an identification with engineering; and in particular the presentation of analysts work in terms of a body of technical expertise; was seen by the majority of analysts, particularly senior analysts as a liability which would alienate them from users and particularly from management.

Recruitment and Skills

Issues of recruitment need to be seen in the context of moves on the part of key bodies like the BCS, IEE and NCC and specific employers to strengthen 'professionalisation'. The IT industry generally has suffered from a poor image largely as a consequence of the number of 'cowboys' that entered the industry at a time of rapid expansion and basic skills shortage, but also because of the high levels of user dissatisfaction and systems failures that have occurred (Willcocks & Mason 1987, BCS 1988). An important consequence of this, and one which Smith (1986) has documented in relation to engineers, is that there has been a rapid increase in direct graduate recruitment into systems analysis at the expense of both technical college, in-house, and general labour market recruitment (NCC 1985, NCC 1994). In effect, this has resulted in a broad rise in qualifications within systems analysis commensurate to similar increases within other professions (NCC 1994, USR 1994). However, graduate recruitment *per se* and certain types of graduate recruitment, in particular, were reported to me by a number of systems managers and analysts as not being without their problems:

> I recruit graduates straight into analysis and design on the basis of three criteria: do they have the analysis skills? Do they have the technical skills and are they likely to bugger off after one year? ... Seriously, graduate labour turnover is a problem. (Systems Manager, Automotive Components Manufacturer, Wales).
>
> We run graduate training programs where we take on youngsters and sponsor them through college ... We also recruit graduates from the general labour market ... The difficulties begin straight away. Firstly, graduates tend to be high flyers. They are in big demand and they know it, and can demand high salaries and benefits. Secondly, they usually anticipate rapid promotion irrespective of merit ... (Systems Manager, Large Financial Services Company, Scotland).
>
> I have been recruiting staff into systems for more years than I care to remember ... We have graduate recruitment paths like most organisations ... and we have good and bad graduates from them ... In the past some of the graduates coming from computer science degrees were bloody awful ... Heads full of technical jargon, glasses and white coat types, not the most ideal people for senior posts, like analyst and project manager, which require human skills, common-sense, communication ability and political nous ... Of course, things are getting better and colleges are teaching more rounded skills ... But you can't substitute for experience and the learning curve of being in work, having your butt kicked, making mistakes, learning who and who not to antagonise, who pulls the strings, what the organisation is all about ... I've found that some of our best people, particularly on the analysis side, are redeployed users, people from within the organisation who know how it works, who understand power, and who, above all, else are loyal. They've probably been with us years, are settled in the area, married with kids, and not about to get up and leave. Personally, I prefer recruiting these types or, alternatively, a young lad or lassie from school, who shows some initiative and outgoing personality and who can pass our assessment and psychometric tests ... You can train these up in your culture and methods

> and they tend to be far less snotty and more loyal than graduates (Systems Manager, Aerospace Industry, England).

A general concern of systems managers was not only high graduate turnover (many managers simply felt it was not worthwhile making the investment in graduates because of this and preferred to recruit in-house from redeployed users) but chronic shortages of skilled personnel *per se*. Thus, one interviewee responded:

> I have to be honest and say we are so desperate, we will take anything going (Systems Manager, Automotive Components Manufacturer, Wales).

Systems Managers also voiced concern about the abrasiveness of graduates. They were perceived by some to be 'snotty' and 'arrogant' and this was deemed a liability for such a delicate and sensitive post. Smith (1986, 1987) notes a similar display of hostility amongst non-graduate engineers to recently graduated engineers. More importantly, many systems managers I interviewed were concerned about the lack of experience of graduates, arguing that they tended to be 'wet behind the ears' and lacking the organisational and social skills deemed to be important to the analysts job. It was also felt that at a time when systems departments were themselves coming under tighter financial and auditing constraints, they could not afford the salaries, benefits and promotional opportunities that many university graduates expected. Even stronger concern was expressed about the overly technical content of many computer science degrees and the type of people which these produced, i.e. 'techies' who were seen as inappropriate to the job of systems analyst. One interviewee put it succinctly:

> I couldn't imagine a worse animal for the job of systems analyst than a computer science graduate ... In my view, people with non-technical degrees make better analysts. The reason is personality. Someone with an arts degree is far more outgoing and choppsy, open and able to communicate and to smooth systems implementation, rather than introduce it as some sharp cataclysmic jolt. Computers are about people: if you can't communicate, you can't gather information needs ... Therefore, you are useless as far as analysis goes ... 'Techies' on the other hand are quiet shy and introverted, reserved and would like nothing better than to go home and take their screens to bed with them ... I run psychometric tests on all our staff and on other companies staff and I can tell a 'techie' a mile off ... The fact that most systems designed in the past were designed by techies is one reason for the mass of failed systems around and the bloody awful image the computer industry has ... Techies do not like change, yet it is they who are supposed to be at the forefront of change. I couldn't imagine a worse type to be in charge of change ... These people are frightened and resistant to change, a breed apart, scientists in their own right ... but ... completely out of touch with business needs (Director of Software/Consultancy House, Wales).

This lack of business, communication and social skills in computing graduates was a factor emphasised by a majority of interviewees:

> Companies are finding an immense shortage of IT people with sound business skills ... who can hold a sensible conversation with business professionals (IT Consultant, Major UK Consultancy, Wales).

Friedman and Greenbaum (1984) found the same. DP managers were looking for 'Renaissance people': generalists, with business experience, who would fit into 'flexible team structures'. Buckingham makes the same point:

> The analysis of information needs, and the design of systems to meet them, requires far more than ability to apply computer technology. It demands also a knowledge and understanding of human organisations and the process of decision making, of the structuring and management of information, of methods of quantitative analysis and modelling, of methods of human communication and interfacing with computer systems, and of proper project management. This differs, in major respects, from the education and training required, say, by a computer technologist or software engineer (1988: 37).

One of the problems, however, and one which Buckingham ignores, is that systems analysis may form only one part of a much larger skills set, where other factors (like technical knowledge) may be as great or even more important. The reason for this is that systems analysis, itself, may be only part of a broader job remit as IT labour becomes more multiskilled and polyvalent (Friedman 1989).

The problem then for colleges and universities is how to deliver the requisite skills within the confines of a three or four year degree course. As one university lecturer and course leader commented:

> Each year our computer science degree has got broader as we try to keep up to date with not only changing technologies - hardware, software and methods but changing practice ... It's becoming a nightmare. We have those at the front end of IT telling us there's too little social science ... We have industry crying out for bloody COBOL programmers for Christ's sake! We have others requesting we include more software engineering tools ... We are trying to please everyone but in the end pleasing no one [and] certainly don't produce good analysts ... Sixty per cent of the degree is at the back end: programming, maintenance, languages, etc. (Senior Lecturer, Computer Science, University, Scotland).

Concern over the content and usefulness of computer science degrees was strong:

> To be frank, we are worried about the content of many computer science degrees ... They produce technical whiz-kids ... mathematically astute and technically proficient but poor at the job of being able to design a real live system that you and I have to live and work with ... Okay its easy to blame the educational system ... *I'm* not ... It's a difficult one ... You can revise courses, put in more business component, take out more COBOL programming, add more 4GL and CASE technology, redefine the approach as in the development of software engineering or use of structured methods, like SSADM ... I'm not sure there is a one best answer (Systems Manager, Japanese White Goods Manufacturer, Wales).

There is also a tendency for the duplication of skills and training within the industry. Irrespective of whether graduates may already possess a computer science degree, they are often put through in-house training programmes and courses. Ironically, many of the systems analysts I interviewed had no formal systems analyst training. It was just something they 'gravitated into' both as part of a career progression out of programming and quite often because 'there was no-one else to do it'. The majority of these analysts undertook the four week course commonly run by consultancies like Hoskyns, at the end of which they obtained the NCC certificate in systems analysis.

The most common recruitment path into systems analysis was promotion through the ranks. This view was cited as producing people with 'in-house knowledge' and good IT skills grounding. But it, too, had its critics:

> The systems analyst is someone who comes up from a programming background - a progression insupportable, in my opinion, as such a background reflects in the systems analyst being overly technical, or computer orientated, in their outlook, a fact which doesn't facilitate them in coming to grips with the business aspect of the work (System Manager, Large Private Utility, Wales).

> When you come up through the traditional path of programming you are not trained to be an analyst: you merely grow into being an analyst ... When I'm doing analysis I find that because of my training as a programmer, I have to constantly battle to fight this pull towards looking at the system in terms of how easy it will be to code, rather than considering whether the system meets business requirements (Systems Analyst, Large Private Utility, Wales).

Paradoxically, although the majority of systems analysts I interviewed had progressed from programming, and although they referred to this route as producing the wrong sort of people for analysis, they were still pleased to have travelled this route, feeling that it added to their ability to design systems:

> Theoretically, you don't need to be able to program to be a systems analyst, particularly if you are doing all your design using 4th generation technology ... But personally, I feel I design better systems because of being a programmer ... There's a logic and purity about it, it helps you understand the implications of your design proposals, you know how to handle programs and suits of programs ... You won't end up designing systems that are an impossibility to program ... You also develop a good grounding [not only] in the strengths and weaknesses of various languages but also the limitation of the hardware and understanding of user interfacing, costings, etc. (Systems Analyst, Magnetic Tape Manufacturer, Wales).

Armstrong (1989, 1991) and Weiner (1981) have documented how management culture, particularly in countries like Britain, is anti-technical and penalises those who couch their claims to corporate power in terms of technical expertise. Many systems analysts, and particularly systems managers, recognise that career progression is intimately tied into senior management's perceptions of whether or not they have taken on board the requisite business acumen and culture:

> Whilst I started off in programming and was heavily involved in the technical side of computing...and it still gives me a buzz...its not the sort of thing I shout about in management circles....What counts here is that you can speak their language, understand their objectives and culture, show that you know what is good for the organisation....You will not go far if you do not have these skills and if you do not impress management with them (Systems Analyst, Financial Services Company, Scotland).

> You must distinguish clearly between a theoretically perfect technical system - one that from a programming perspective does everything asked of it and a system which does what users and management want of it....gold medals are not given out here for technical brilliance and I would suggest if you push that line you will rapidly be seen as a misfit by users and user managers (Senior Systems Analyst, US Electronics Multinational, Scotland).

Clearly, analysts recognise the importance of technical and particularly programming skills. The more astute however, also recognise the need to repress their enthusiasm for this aspect of their work when in the company of management. I found that quite often analysts felt uneasy about discussing their technical expertise. They would silently acknowledge its importance whilst continually stressing that they were, nonetheless, business orientated. Analysts often subordinated the continued importance of technical and particularly programming skills to their job and sense of self worth to what appeared at times to be an insincere business rhetoric. This produced an almost schizophrenic atmosphere in many of the systems departments I studied. Such schizophrenia is reflected in the attempt on the part of many organisations to provide dual career structures for IT professionals - to reward both technical and social skills alike. However, from the analysts' point of view this dual career model is inappropriate in that no analyst I interviewed wanted to be placed on the technical ladder. All wanted to be placed on a managerial one and duly recognised for their managerial and business skills.

Many analysts thus repress a central part of their education, training, skills and enjoyment to satisfy this career objective.

General Skills Requirement of Systems Analysts

The BCS argues that systems analysts should have most of the following characteristics:

be literate in English and numerate
have a good general education, preferably to degree level
be able to get on with people
be able to articulate ideas coherently and clearly
be prepared to work hard
be resilient and adaptable
be highly motivated
be able to absorb and apply new technical knowledge (1988: 2-3).

My interviewees confirm this BCS emphasis. Recruits into analysis are, generally, expected to have a degree, good 'A' levels or experience in business, preferably IT - related. There is general agreement that technical degrees are not necessary and that arts or social science degrees are as valid. Analytical and communication skills are given high priority, and there is widespread criticism of computer science degrees, with their emphasis on programming, at the expense of business and social skills. Daniels and Yeates (1986) argue that the systems analyst needs to possess logic, perception, stamina, intellectual discipline, a sense of purpose and a flexible outlook and strength of character; in other words, skill is defined in terms of logic, and personal qualities.

Because of the diversity of personnel undertaking systems analysis, and because of the diversity of applications worked on, from traditional office systems to large scale manufacturing processes, it is difficult to make general statements about the precise skills required. For example, whilst business consultants and systems managers in traditional data processing environments put considerable emphasis on the acquisition of business and social skills others, for example in heavy engineering, also recognise the need for good technical skills:

> To be a good systems analyst in Computer Aided Design (CAD) and Computer Aided Manufacture (CAM), you need to have been in manufacturing and engineering, and you need programming because of the way you have to structure operations ... You have to be able to split various bits of systems and software, and this requires certain programmer skills ... That's why we don't call ourselves systems analysts, systems engineer is a more appropriate term (Managing Director, Software and Robotics Company, Wales).

When one reviews the course content of IT degrees, or BCS, IEE and Systems Journals - trade and academic, and when one speaks to practitioners in the field, one is struck by the diversity and depth of knowledge and skills systems analysts are expected to possess.[4] What we are talking about here is a Nietzchean superman of computing and one needs to question whether or not it is at all possible to embody in one person such a diversity of skills:

> It can be very tiring continually updating skills sets, and it's becoming more so as users get more choosy and technologies change ever faster ... Many of my analysts cannot keep pace ... Some simply don't have the skills sets ... let's say knowledge of particular application or language ... I try to offset this by bringing

in consultant analysts - high fliers ... You pay through the nose for them but they are light years ahead of most of my department when it comes to latest technologies and methodologies, etc. (Systems Manager, Pharmaceutical Manufacturer, Scotland).

You need to distinguish between your analyst, working in a stable IT environment where there is little new innovation and more or less well worn systems of communication and procedure ... from your analyst working in a department that is on fire ... flooded with user requirements, expected to be at the forefront of change ... In the latter department you can get burnt out fast as an analyst ... The way forward, as I see it, is better project management and project teams, bring in more users ... outside expertise, consultants and even analysts and programmers, if you have to (Systems Manager, US Electronics Multi-national, Scotland).

Deskilling of Systems Analysts?

Braverman (1974), Kraft (1979) and Greenbaum (1976) have argued that a process of deskilling is taking place within the computer industry. My own research indicates that the development of certain tools and techniques - for example, structured methods, 4gls, CASE and software engineering tools more generally, offer the possibility of deskilling. However, the majority of analysts and systems managers I interviewed rejected such arguments, and for a variety of reasons:

Bits of the puzzle can be automated [and] we've made enormous inroads in some areas towards making the role of the systems analyst smoother and more structured, e.g. 3D auto CADs, programming generators, paperwork flows, techie flows, third normal form, entity modelling, data flow descriptions, etc. ... But what I call the IPSEs, 4GLs, report writers, systems builders, etc., ... these are not going to substitute for the systems analysts unless they can get out there into the business environment and do the analysis for me (Systems Analyst, Large Public Service Institution, Derbyshire).

Some of the tools and techniques we use include context diagramming, data flow diagrams, organisational diagrams, prototyping, etc. ... Often, however, it is quicker to draw by hand than use, for example, a Yourdon package or 4GL ... Tools and techniques like 4GLs do take away the donkey work but they don't substitute ... getting out and talking to the users and setting requirements ... If you can provide the tools that can say do forty per cent of the analyst's work then you have got an ideal tool ... But the big trouble is with all these 4GLs and everything, that you need big costly computers to run them They are also slow ... and the information you get is only as good as the information you put in ... I find that, often as not, the best systems design comes through smoking a fag whilst having a natter with a few colleagues, using pencil and paper and flip chart which you take an A4 copy of (Systems Analyst, Multi-national Manufacturing Company, Wales).

Structured methodologies make it a hell of a lot easier to do a good systems job, forcing you through the steps a good analyst would do anyway. But there are considerations in designing systems which users, even with the most powerful CASE tools, are not best suited to, such as sizing considerations, ensuring compatibility, corporate usability of data etc. ... If you could devise a CASE tool to do all this and go out and talk to various users at all levels *then* you might be talking about automating the systems analyst function (Systems Analyst, Large Private Utility, Wales).

Methodologies are not God's panacea ... They are certainly no substitute for the skills of a good systems analyst. We use methodologies, particularly for large scale projects. One such methodology is Jackson's Structured Programming and Design ... We've looked at James Martin's Workbench and its a pile of crap ... You can't automate the systems analysts skills (Systems Manager, Large Public Service Institution, Derbyshire).

The whole reason why we want expert systems is that there is no substitute for human experience ... Some methodologies like SSADM are an attempt to partially automate some systems analyst functions and, likewise, 4GLs to automate certain programming functions but neither, in my opinion, will replace the need for analysts or programmers (Systems Developer, US Multi-national, Wales).

It is always cost effective to have a data modelling methodology - but all methodologies are just tools and cannot substitute for the skills and experience of the systems analyst (Systems Manager, Large Private Utility, Wales).

I do not think it at all true that either the programmer or systems analyst functions are being deskilled or automated by new technology and new structured techniques. There is a dearth of good data modellers and no amount of CASE tools will actually teach a person to sit down and sort out entities and

> relationships. This is just a gift you have, or learn ... You can take something like Automate and SSADM and the tools and techniques they provide will help the good analyst to concentrate his mind. Exactly the same as engineering disciplines in the engineering profession concentrates the mind of the engineer into a reasonably constrained and focused effort. (Senior IT Consultant, leading UK Hard and Software House, South West England).

Generally systems analysts felt that, under conditions of severe labour shortage, expanding work loads and demand from users for increasingly diverse applications, they were becoming more skilled. Rose (1987) argues that there is a need to move away from the simplistic work degradation thesis to recognise the diversity and variability of ways of organising computer staff. One can, however, recognise this diversity whilst still accepting that attempts towards assertion of managerial control over the systems design process and the development of tools and techniques to both routinise and deskill analysts work will take place:

> Given that management is about monitoring of deliverables, then methodologies have to be great news for managers in that they allow inspection and breakdown of the systems design process and the systems analysts work (Systems Manager, Pharmaceutical Manufacturer, Scotland).
>
> Without doubt, one of the things about getting systems analysts to use methodologies is that, as a manager, you can closely monitor their work, check they have followed the right procedures, done the correct documentation, etc. ... Some may resent this kind of close inspection, particularly those used to designing systems on the back of a fag packet (Systems Manager, Private Utility, Scotland).
>
> Certain methodologies can be used by managers to monitor and control the work of their systems analysts ... They are a project control and management tool ... They structure the work of the analyst because the analyst has to detail everything ... But there are other tools available to us for monitoring the work of our analysts, including reporting package software, whereby the analyst has to key in what he has done, how long it has taken him, etc., and the computer prints out calculations direct to me, like his performance and productivity,

> quality of work, etc. ... So, yes, these help me manage the output and quality of my analysts' work (Systems Manager, US Multi-national, Wales).

> No-one's out to deskill for the sake of it ... and, in one sense, the most important - the front end or political end of an analysts job, ... [it] is just not possible or desirable to deskill ... the ability to get on ... and the very real need to put people at ease ... But at another level, there are things I can do to monitor my analysts' work and, indeed, to an extent control it ... We introduced software to monitor the number of lines of error-free code produced by programmers and analysts two years ago - they didn't like it but accepted it ... I want to see tighter use of structured methods and particularly SSADM which is a first class methodology ... Software engineering, generally, could also be perceived as deskilling some analyst work ... Software will also be introduced here, when the time is right, ... to monitor analyst output in terms of both quantity and quality (IT Manager, Financial Services Company, Scotland).

Discussion of deskilling needs to be set in the context of an expanding industry with severe labour shortages. According to Oakely

> The future for the IT sector looks bleak. All evidence points to rising demand for IT professionals. Hopes that developments in software productivity will offset this demand are illusory (1989:12).

Houghton (1989) and Towndrow (1988) argue that skills shortages are compounded in Britain by lack of investment in IT and indifference and ambivalence on the part of the UKs top managers. Given the persistence of skilled labour shortages in the industry (NCC 1994) one could reasonably expect professionals within the industry to secure good terms and conditions for their labour, and indeed, this is what appears to be happening. Harris (1975) and Rose (1987) argue that where job losses and deskilling is likely to have greatest impact, is on operating staff, i.e. those running large mainframe installations, as shifts towards more powerful micro and mini computing, and dissatisfaction on the part of users with traditional DP systems design grows.

The majority of systems managers and analysts I interviewed believed that it was neither possible or desirable to automate or substitute for the `front end' - interpersonal, communication, organisational and business skills of the analyst. Getting user requirements and acceptance to a particular system is perceived by the majority of systems managers and analysts as a process requiring `nouse', `intuition' and `experience'; these are perceived as highly valued characteristics which cannot readily be substituted.[5] Ironically, the move towards engineering standards and structured methods on the part of professional bodies like the BCS or IEE downplays the importance of precisely those skills deemed so vital by practising systems managers and analysts.

Systems Analysts Values

Technical Rationality and the Analyst

Implicit in much of the work of systems analysts, is a technicist ethos, similar to that displayed by engineers. Habermas (1971), Ellul (1964) and Mumford (1970) are among those who have commented on this as a general, albeit pervasive phenomenon. More specifically, in relation to systems analysts, Mackay and Lane (1989) have documented two consequences of technical rationality: first, systems analysts tend to have a strong faith in the capacity of IT to solve human problems; second, despite some analysts acknowledging design is a political process, the majority of analysts take account, only marginally, of the human, social and political elements of systems (Mumford 1972, 1981, Bjorn-Anderson & Hedberg 1989, Newman & Rosenberg 1985, Murray 1989). The majority tend to consider the political, only in terms of the politics of information extraction, and the process of manipulation of users to get the system requirements. In effect, they consider the social and political aspects of systems design only inasmuch as it influences their job of analysis; the ramifications of their designs on users are largely left to others to deal with.

This is not to say that analysts were not aware of the ramifications of their designs on the organisation and control of others work and their possible impact upon jobs and skills. Rather they were visibly unhappy about discussing analysis in these terms, particularly if as a consequence of their designs significant job losses or deskilling of others work had occurred - at which point, they would invariably seek to invoke the sphinx of technical rationality, justifying their designs in terms of lesser evils.

Obviously, at one level, having such a viewpoint serves to comfort and cushion the impact of systems analysts work from the systems analysts themselves:

> Your traditional DP environment, with its thick technical coat, tends to isolate the systems analyst from the broader consequences of his work [with] political considerations tending to be left to others ... It is easier then for the analyst to comfort himself in the knowledge that his own decisions are purely technical and

> done solely for technical reasons ... Obviously even with this thick coat many can't face the consequences of their designs and have deep personal traumas (Systems Manager, Multinational Electronics Company, Scotland).

The DP culture with its traditional routes of entry into analysis, up through programming and via recruitment from technical degrees, with its heavy emphasis upon control and systems theory and the 'hard' sciences, helps to foster a technological paradigm within systems design. This is reinforced by the division of labour within systems design. Analysts usually carry out their analysis in project teams, consisting of users and systems staff, which serves as the crucible in which strategies and important political decisions are 'democratically' melted down. Likewise, senior staff, i.e. project manager, systems manager, or above, tend to make and be responsible for, the strategic political decisions within a given design.

As with engineers (and unsurprisingly) many analysts perceive the accumulation process as essentially technical, and accounting and profit as an indicator of systems success, rather than as (for example) an indicator of labour exploitation. Because accumulation is seen as technical, rather than social, analysts can perceive their own work in likewise technical terms: they are the ones ensuring that inspection, monitoring, overseeing and control of organisational functions is carried out 'effectively'.

Wedded to this notion of technical rationality is a model of the analyst, as information technocrat, within the new information society economy (Bell 1984, Naisbett 1982, 1990, Toffler 1980). Here we have a similar theorisation to that of Veblen who saw engineers as the rightful heirs to the process of industrial capitalism, the ones most suited in terms of skills and training to be the guardians of production and society. If engineers were perceived as the technocrats of early 20th century capitalism, a number of analysts and systems managers perceived a similar role for systems staff, as the new technocrats of the emerging information economy:

> If steam, coal, machinery and production line technology were the base line of industrialisation ... information and information technologists will be central to the new post industrial ... leisure society (Senior Systems Analyst, Financial Services Company, Scotland).

Whilst the majority of analysts and systems managers I spoke to were less sanguine about the coming of a new post-industrial information society, there was, nonetheless, a general consensus that systems staff will be key personnel in the 21st century economy:

> Information is the key to business success ... The revolution is only just beginning ... I see massive demand in the years ahead for systems staff and, in particular, excellent analysts who will be at the forefront of this revolution [and will be the] catalysts ... advancing the technology (Systems Analyst, US Multinational Electronics Company, Scotland).

In sharp contrast to the often run-down departments, facilities, tawdry image and low self-esteem which I encountered in my field studies of engineers, in systems departments I found staff with a glossy high tech aura about them which conveyed a sense of optimism. They were riding the crest of a technological tidal wave that they perceived was about to come crashing down on an unsuspecting and often unprepared business community, rather than receding into the prehistoric past like many engineers. This was recognised by both the systems analysts and engineers I interviewed:

> We are at the forefront of changes in manufacturing and, indeed, society generally ... ours is a high tech holistic technology that permeates every aspect of life ... Its potentiality is only just being realised [and] the pace of change is fast in this industry ... You've got to be young, fit and have flair and intelligence to survive but the rewards, in terms of income and status, can be immense if you are a high flier (Systems Analyst, Financial Service Institution, Scotland).
>
> I suppose IT does have a better image than we do ... Engineering is a low status and ill-rewarded occupation in Britain ... People want to leave this profession before they've even started ... I and many of my colleagues, get pissed off with the ridiculous money and prestige systems staff can get in this company ... It's out of all proportion to their skills and training (Mechanical Engineer, Pharmaceutical Manufacturer, Scotland).

Whilst the engineer was perceived as working with tools and getting dirty and oily, the analyst was seen as working with knowledge - an esoteric commodity, one that bestowed higher status, was cleaner, more important and more central. This point was made forcefully by one young analyst I spoke to in one of Britain's largest clearing banks:

> The substance of our work is communication ... Knowledge flows, knowledge processes ... It's a far more esoteric commodity than a car engine or machine tool ... This knowledge is central to business success and central to society ... we don't carry bags of spanners around ... What we carry is the formal and informal politics of the organisation and of who does what and who should do what here in our heads (Systems Analyst, Major High Street Bank, Scotland).

Analysts tended to see themselves as modernisers. In my research I sensed both the urgency and the centrality of their work to organisational effectiveness. This was reflected not only in terms of the number of new posts created, the plushness of offices and furnishings, the restructuring of company boards to give greater voice to IT representatives but, more importantly, in everyday organisational discourse: talk was of changes in, or modifications to, work practices, operating systems, new communication flows, robotics, computers and more computers. This contrasted sharply with the discourse of worry about closures cutbacks and deteriorating status that many engineers experienced.

Technical Rationality and Disaster Planning

I found, however, that systems analysts' notions of technical rationality and their visionary perspectives concerning the future information society were thrown into sharp relief in my interviewees discussions of IT fragility and disaster planning. This is one area where the majority of systems managers I interviewed expressed concern, worry and notable unease. Several cited examples of the fragility of their systems:

> We have a planning section whose job it is to put through disaster plans and we look for possible weaknesses or vulnerability within the system. I am very aware of the responsibility on IT for trying to minimise fragility ... We try to build flexibility into the systems we design ... But let's face it, NALGO could pull the plug on the mainframe and grind us to a halt (Systems Manager, Large Private Utility, Wales).

> Disaster planning becomes very important, as more and more of your strategic operations become computer reliant. The plane that crashed on the M1 caused a real fright to Bank Co. It missed their main computer building by a few hundred yards. The real disaster, however, is not so much a bomb blowing the mainframes up, as to how to keep your data current, as systems become ever more complex. Think of the risk to ATMs if mainframes went down, in fact to

all aspects of banking ... and how do you plan for things like industrial action? (Systems Manager, Major High Street Bank, London).

Many interviewees referred to the fragility of systems in terms of potential fires, industrial action, etc. Others, however, saw fragility in more sophisticated terms, viz., of what IT did not have, that manual procedures do:

> To a certain extent, our CAD based system, could be said to embody a certain deskilling of the craftsman's feel for the part and his experience of the metal. This can be lost in a computer-aided design system as you become over reliant on drawings rather than on experience and feel. It's a problem and one reason why you shouldn't employ non-engineering trained people to design on CAD ... We used to be a paper factory. Paper factories have a certain flexibility, now we are moving fast towards a paperless factory ... which can be very fragile. You need to build in safety factors, duplication of essential functions, security, etc. otherwise you are asking to be cream crackered ... There is a hell of a delicacy and lack of flexibility about a fully computerised factory ... We got one hell of a hammering from the auditors ... shit flew [and] they said we were totally vulnerable and couldn't function without a computer ... It's one reason why I am currently in the middle of producing a justification report to ensure adequate disaster planning ... But of course you can't plan for every contingency: industrial relations, a nutter, a miss-keying of information ... it's a nightmare ... I can see big problems for some companies in the future (Systems Manager, Aerospace Industry, England).

Cooley argues that factories that are nearly workerless lack robustness:

> If you have highly skilled workers who understand the system then you will have a more robust system in the sense that it can cope with a whole range of uncertainties and disturbances - and the real world of manufacturing is always full of uncertainties and disturbances (Cooley cited by Gannon 1988).

Cooley, working on a project concerned to counter the Taylorist approach to the elimination of uncertainty, is aiming to develop human centred systems which enable the operator to over-rule the machine, as opposed to ones which minimise operator skill:

> Automated systems work well in an ideal world. As soon as you take computer systems into the real world they hit unexpected problems (Slaven, cited Gannon 1988).

Cooley's approach has been articulated by others. Caulkin (1989) cites examples to show that computerisation and automation are not panaceas for all business ills. He argues that more often than not, less computerisation will mean more competitiveness and flexibility and that the answer lies in getting the right blend of organisational culture, skills, product structure, suppliers and investment in IT:

> Manufacturing goals these days are summed up in one word, zero. Zero inventory, zero delay for the customer, zero defects, zero batch size excess, zero bureaucracy, zero industrial conflicts with labour. For the time being most firms have a better chance of achieving the aims of new manufacturing with a PC and a drawing board than with all the MIPs in the world (Caulkin 1989).

In the same vein, Evans (1989), Adler (1987), Kelly (1986) and Clarke(1995) have examined the low take up of CIM and FMS, arguing that manufacturing needs organisational change, not necessarily more computing capability.

The possible fragility of IT systems means that, the logic of many systems analysts and systems managers - that more IT is better - often crashes upon the rocks of organisational practice, in which more IT can simply mean more fragility and more nightmares for systems managers. A number of systems analysts, and particularly systems managers, were aware of this contradiction indicating that this was a sign of their maturity and the fact that they were not merely 'techies', like many in the field:

> There are many systems I have looked at on the shop floor and decided to leave well alone, either because they were too complex to computerise or operations are so simple and efficient as they are, that to computerise under present levels of skill and job demarcations, etc., would just cause too many problems and wouldn't be worth the hassle. I don't believe in developing computers for computers' sake. I am more an engineering man than a computer man (Systems Manager, Automotive Components Manufacturer, Wales).
>
> In this business you've got to know when it's worth computerising and when it isn't ... I have to restrain some of the younger lads who are keen to computerise everything in sight ... Some operations are best left as they are ... for example, there are a number of highly skilled - and I mean highly skilled - craftsmen here. I was pressured by salesmen to introduce CIM and a certain amount of automation ... But, unlike the sales reps, I know the firms' product structure and value the flexibility and skills of the shop floor ... It's better left alone [and] production management agreed with me ... I think they were pleasantly surprised that I wasn't just trying to advance our department but actually thinking in terms of the broader interests of the organisation ... In fact, I was promoted several months later to systems manager and I'm sure this played a part in it (Systems Manager, Japanese Electrical Goods Manufacturer, Wales).

Sargent argues that systems designers need to be aware of failures which

> are important learning situations because they ensure that designers will in their future work properly explore the new design idiom these failures represent and the possibility of failure [as] part of the culture of engineering (1994:391).

However the drive on the part of organisations like the BCS towards the development of systems analysis as a design science with a coherent, logical and fail safe, set of methods, tools and techniques, fails to acknowledge the essentially incoherent and contested nature of design and the variety of competing design tools, techniques and paradigms (Sargent 1994, Vincenti 1990, Warfield 1990, Bucciarelli 1984). Consequently, as Sargent argues

> Any design science is therefore strictly limited in its predictive power except in very mature domains using very well established design idioms - in these cases it is arguable whether such a routine process is design or whether it is mere form-filling (1994: 392).

The prescriptive nature of the industry and much of its tools and techniques encourages analysts to `get it right' first time. Consequently analysts have not yet grasped, as many engineers have grasped, the significance of failure as part of the learning curve of successful systems design (Petroski 1985). It is only because of increasing user dissatisfaction that recent developments in prototyping software are now giving analysts the possibility of creating models that can fail and that failure itself is slowly entering design discourse. In this sense analysts are beginning to realise what many engineers have known for a long time - that an engineer is someone who turns specifications into malfunctions (Seargant 1994).[6]

Business Rationality and System Efficiency

If technical rationality was the old altar upon which systems analysts both worshipped and were slaughtered, 'business rationality' is fast becoming the new one. Systems analysts and managers would justify their autonomous decisions - including less IT if necessary - in terms of their understanding and interpretation of what the organisation needed. Many analysts and systems managers saw themselves as the 'guardians' of the organisation, the new high priests, whose unique technical and business skills, coupled to their key location within the division of labour, gives them a 'panoramic' perspective that users may not have. This places them in a uniquely favourable and privileged position from which to make pronunciations regarding what is the most suitable strategy and design to pursue:

> I would say that analysts, and the department as a whole, because we are a service department, with fingers in every other department ... because we know their business ... because we write the systems for their business ... because more than anything else we know them and how they think ... we more than anyone else within the company should be in a position to know what's best for the company (Systems Manager, Private Energy Utility, Wales).

The higher one progresses up the systems hierarchy, the more important overt display of business awareness becomes. Career progression is intimately tied into senior management's perceptions of analysts understanding of business and their organisational and communication skills. Two factors are responsible for the rapid rise of business rationality within systems design. First, the immersion of analysts into dominant business cultures has been greatly reinforced via a new emphasis within government and managerial circles of the virtues of the 'free market'. Almost without exception, the companies and organisations I studied, including the public sector, had undergone processes of restructuring both in terms of job losses and rationalisation of processes but also, and importantly, in terms of new organisational cultures, emphasising 'cost effectiveness', 'reduction of waste', 'slack', and the 'need to end restrictive practices'. Second, the shift towards graduate recruitment and the increasing emphasis upon business and organisational skills within degree and course curricula has helped foster a culture in which graduates see themselves as part of management and anticipate managerial rewards.

Many of the analysts I interviewed used notions of 'business rationality' to explain away their designs, often almost confessionally. My suggestion that market needs are open to interpretation and that analysts might be interpreting them in a particular way, simply to justify their particular systems design was often met with a near religious invocation of the market and market principles:

> I don't determine what the market needs ... The market is neutral ... I simply deliver systems that the market dictates ... I don't personally choose or desire to see people lose their jobs, or carry out less satisfying forms of work ... If I didn't build systems this way, the market would penalise us all [and] we just wouldn't be competitive (Systems Analyst, Japanese Electronics Company, Wales).

At a practical level, unitarist perspectives, like technical or business rationality, with their emphasis upon 'efficiency', either technical or business, but invariably both, can save analysts a lot of soul-searching, for example, not having to become overly emotional about job losses, deskilling or routinisation of others work:

> I have designed systems where I have had to take away decisions from users ... because it would complicate their tasks [and] run the risk of messing up programming (Systems Developer, Hardware/Software Manufacturer and Consultancy, Wales).
>
> Sometimes it is necessary to alter job definitions as a consequence of systems developments. For example, in banking a lot of our systems were designed expressly to shed labour and increase productivity ... But it has to be done, if we

are to remain competitive and efficient (Systems Analyst, Major High Street Bank, London).

If you look at the operatives in this mill ... Look at them (analyst gesticulates with finger to shop floor) ... Many are trained gorillas ... You can't blame *them* ... but really I'm not going to give them the opportunity of wrecking my system by getting them involved in the design stage or offering them all kinds of options ... You cannot jeopardise efficiency for the sake of a few hot heads ... The interests of the organisation must come first or we will all be out of a job (Systems Engineer, Automotive Components Manufacturer, Wales).

Analysts justify their designs in terms of 'efficiency' but never really define or question the concept. It serves as a prayer, whose continual rendition serves to obliterate enquiry. What is more, the continual repetition of the symbol is not without its problems. The eagerness of many analysts to enter the discourse of business efficiency - matched only by the crispness of their blue suits - was often parodied by users and even older, senior and, in this instance, presumably wiser systems managers:

It's okay rushing round preaching "modernise, modernise" ... "efficiency improvements" here, "cost savings" there ... God they make me cringe sometimes ... I have to restrain some of the younger analysts' enthusiasm ... and at times I wish they would be a little less business orientated ... Well, er ... I mean less bloody open and proselytising about it ... What you need to appreciate is that in this company people get set in their ways ... Users don't readily grasp or even appreciate the need for change ... We're not some financial company full of yuppies [and] even management here gets its hands dirty ... Some of my analysts really piss some of the users off ... I've had them come up to me and complain .. One manager said, "Are all your youngsters [expletive] Tories or have they just swallowed Milton Freidman" ... It's not the way to go about design ... You need to be more subtle ... (Systems Manager, Heavy Electrical Engineering Company, Scotland).

I'm not a fanatic and I hate fanatics [and] this new business creed worries me ... I don't particularly like the ideas many of my younger graduates have ... I don't like their attitudes either ... They can be too abrasive and abrupt ... I've worked as System Manager in this company for years. If I don't need an Italian Designer suit, why do they ... This job's not about antagonising people it's about facilitating them in securing their aims ... Some of my analysts frighten users with

> their creed of change ... it's just unnecessary and naive (Systems Manager, Regional Power Generating Utility, Wales).

What these managers are alluding to is that the doctrine of 'efficiency' - technical or otherwise - is just that - a doctrine. It doesn't square with the reality of systems design as compromise, and it upsets and alienates many users whilst in the process ridiculing systems departments through its evangelistic creed and pronunciations on organisational problems. As one systems manager put it bluntly:

> Free market philosophy and business efficiency is meaningless ... There is no free market ... and all systems are compromises ... We are lining ourselves up for a good kicking if we approach systems design with the attitude we've got the most effective, efficient solution to your problems ... I say to those peddling such a philosophy shove it ... and leave design to the professionals (Systems Manager, Electronics Contractor Defence Sector).

Whilst the majority of systems analysts I interviewed and observed justified their work in terms of business or technical rationality, and in most cases both, there were a couple of notable exceptions, including one young analyst. He related how he could not face integrating a particular work station into the broader CIM facility, as he knew it was going to mean two of his best mates would lose their jobs (these were childhood buddies, who lived in the same village, went to the same school; indeed, one had been best man at his wedding):

> I was working on a team introducing new CIM facilities, part of my remit was to analyse job functions in assembly "B" with a view to automating procedures there ... My pals worked there ... I was dreading it ... I priced several bits of hardware and robotics ... I did my best to find the most expensive and elaborate

> ... In my presentation I emphasised the difficulties that might emerge in installation and the cost and lack of flexibility ... I portrayed the whole exercise negatively ... emphasising how efficient and well the current system worked and how disruptive and costly it would be to alter. I was lucky they believed me, probably because they never seriously questioned my figures ... and probably because the budget was running ahead anyway ... But I could, if I had wanted, persuaded them to go automatic ... It was so irrational ... so unprofessional ... I felt guilty for weeks ... I still do feel guilty but my loyalty to my friends is more important than to the company I suppose ... (Systems Analyst, Japanese White Goods Manufacturer, area omitted at interviewees request).

What is remarkable about this admission is not just that the analyst recognises that systems are often the outcome of 'irrational' choices, but that he felt so guilty, both in terms of not being loyal to the company but also in terms of disregarding the dominant culture of 'efficiency' within systems design.

It should also be noted that whilst many systems analysts were waiting in the wings, ready for the limelight to fall on them in recognition of their incorporation into the business community, others were far from happy at the prospect of entering that community or having their work presented in such overtly business oriented language. One systems manager argued that traditional DP environments with their thick technical coats tend to cushion some analysts from the political ramifications of their designs. Some, because of their particular training and career progression, up through programming, were probably best left at the back end, out of the limelight. The sheer weight of analysts who have come up through the technical ranks should caution the making of sweeping statements that all are ready to grasp the business mantle. More importantly, a minority simply do not wish to accept this mantle because they do not accept the dominant business ideology:

> I suggest that a lot of those you may study working in the high tech, high flying companies and areas ... and particularly the younger ones, will have a pretty uncritical stance towards the business credo sweeping through systems. I personally am not a monetarist, I'm a socialist ... at heart. I know that there are conflicts of interest within organisations between those that own and those that don't ... I see myself as trying to be humane ... I have to fight constantly to resist unthinking calls for IT ... from some of the younger personnel (Senior Systems Analyst, Large Private Utility, Wales).
>
> I could be earning far more money if I were an analyst in the private sector ... but I'm not prepared to sacrifice all my principles for the sake of personal greed and company profit ... I feel that here there is less accounting pressure on systems and more scope for people centred systems development ... the kind which, in my opinion, makes for not only a happier workforce but healthier organisation (Systems Analyst, Regional Council, Scotland).

Productivist culture

Like the engineers discussed in the previous chapter, many systems analysts conceptualise their work in similar productivist terms. The analogies with coal mining and getting down to the coal face and getting ones hands dirty, frequently entered systems analysts' discussion of their own work. It is as if they draw strength and self-esteem from emphasising the directly productive nature of their work:

> We don't just sit around pushing pens and doing paper work ... We get down to the coal face - talk with the users [and] get things built (Systems Analyst, Automotive Components Manufacturer, Wales).

> Above all else, we are designers [and] engineers ... We build systems - physical systems ... The nature of our work involves us getting our hands dirty ... getting out to user departments ... sorting out their requirements ... Physically building the system ... and maintaining it (Systems Analyst, Large Private Utility, Wales).

Ironically, discussion of analysts' tools and techniques took on a similar macho tone. Tools and techniques were described in terms of 'toolkits', with emphasis placed upon their 'engineering' content:

> We can pick and choose from a variety of tools when it comes to design ... I have my own personal toolkit which I prefer to use and other analysts have theirs ... Which particular tools you use depends on the situation you are modelling (Systems Analyst, Major High Street Bank, London).

Listening to systems analysts one could be forgiven for thinking they actually had a bag full of tools which they carried around with them from job to job, rather like a mechanic or plumber, whereas, of course, the tools and techniques they are referring to are paper methodologies and computer software neither of which tend to leave the systems department.

Ironically, systems managers, rather like senior engineers and production engineers, whilst still emphasising the productivist nature of their staff's work, are less sanguine about presenting this work in terms of a vocabulary of production, seeking also to emphasise more esoteric qualities like managerial, organisational, inter-personal and communication skills:

> Obviously, we have a whole series of tools and techniques that we deploy in building systems ... these are heavily engineering orientated, particularly the new Case tool kits and new Virtual Reality Software that we are beginning to use to good effect ... But one should not forget that we are not engineers as such ... Our work is also managerial ... increasingly more so I would suggest (Systems Manager, US Multi-national Electronics Company, Wales).

> It's important to recognise that our work is productive ... but I'd caution those trying to advance the cause of systems in such terms ... Analysis is more managerial ... requiring inter-personnel and organisational skills as well ... It's unhealthy to make too close an identification with production ... (Systems Manager, Pharmaceutical Manufacturer, Scotland).

It is possible that these two managers recognise that status and career rewards do not come from identifying too closely with the vocabulary of productivism. Too strong an emphasis on the practical and technical content of their work may discredit them in the eyes of senior managers and users. Certainly, the blue suited image and shift towards graduate and in-house recruitment, with emphasis on non-technical degrees and business understanding, would seem to indicate that systems analysts are becoming less wedded to productivist values than engineers.

Design Purity

I found that systems analysts, rather like engineers, had strong opinions on what constituted a 'pure' design. Unlike engineers, however, who utilised imagery of Italian engineering to epitomise design purity, systems analysts, albeit unconsciously, utilised Weberian imagery of technical-rational efficiency:

> Systems should be efficient ... By that I mean they should have singularity of purpose ... Ideally they should not be compromised ... and cluttered with too many bells and whistles ... which require inordinately long programming hours and, anyway, divert the user from the task in hand ... When I go about designing a system, I consider what the user's function is and how I can apply the technology to enable the user to carry out the function, more rationally ... more efficiently ... (Systems Developer, Regional Water Authority, Wales).

The vocabularies of systems analysts and engineers are very close here: both refer to the need to follow form and cut back on unnecessary complexity and details - an 'over engineered' state. Both utilise notions of design purity to legitimise and evaluate their own activity:

> Of course, I could have given users this and that ... but this would have infringed the solidity of the design ... It's not wise to give too much decision making to users, if you can actually encompass that in the software ... Your system will be more robust and less prone to crashing (Systems Analyst, Automotive Components, Manufacturer, Wales).
>
> You don't compromise the design of the system just because of human factors ... Users have their own particularistic interests ... You can never please all users and that's not my main concern ... My concern is to deliver a system that's pure, uncomplicated and fulfils the requirements set by management (Systems Analyst, Financial Services Institution, Scotland).

The first analyst argues that giving users too much input and autonomy would compromise the solidity of the design. The second argues that you cannot compromise the purity of the design simply because users may be upset or dissatisfied by it. In effect, notions of design purity act to cushion analysts from the implications of their designs on users and to legitimise their own practice in terms of a higher rationale than merely 'particularistic' user interests.

Interestingly, as with engineers, a number of systems analysts felt their designs had been, or could be, compromised on the altar of cost benefit analysis and user sanctity:

> Obviously, there are systems we have worked on here which could have been a lot better ... But they ended as compromise because of lack of funds and financial insight (Systems Analyst, US Electronics Company, Scotland).
>
> Our intention is to support and maintain the user functions ... but users do not always appreciate the issues or complexities of a particular design ... But, because you are there to support them and not vice versa, you sometimes have to compromise the purity of the design ... The design becomes less than ideal from our perspective (Systems Manager, Regional Energy Utility, Wales).

Implicit in this is the notion that there is some abstract model or set of values that analysts work to, a higher rationality, or sense of purpose, concerning what a system should look like and how it should function.[7] Ironically, given the number of analysts who emphasise that design is invariably a compromise, one wonders why such a rationality should be so pervasive. One possible explanation is that notions of design purity, along with other values (for example, technical and business rationality) act to constitute a particular world view which, in turn, reinforces the role of systems analysts as corporate guardians. In effect the notion of design purity serves to legitimise calls for privileged status and position. This in itself is interesting because whilst systems analysts and particularly systems managers continually reiterated that their role was to 'support the user functions' they also felt that users did not always know what was in either their own, or the organisation's, 'best interest'. After several years interviewing and observing systems analysts and systems managers I am left with the clear impression that many of them think, but few will openly state, that they should have privileged status and more organisational power commensurate to their roles and strategic importance to the organisation.

Systems Analysts Autonomy

The majority of systems analysts and even systems managers interviewed did not like to acknowledge openly that they had a degree of autonomy over systems design, and even less would they admit they used this autonomy. Many panicked when I pressed them on the issue of autonomy over the design process, not only asking for the tape recorder to be switched off but visibly blushing and becoming uneasy.

Whilst a number of analysts and managers refused point blank to discuss the issue of autonomy, contenting themselves that they were merely 'executing user requirements' and 'working to spec', others were more forthcoming:

> Nobody can develop a system without imposing their own personal preferences and views upon it, so I suppose this is an area where we have autonomy ... We are able to engineer into systems our own particular world view, we shouldn't but we do ... (long pause and consternation) ... Er ... what I mean is ... er ... it can be dangerous, particularly, if you are a rookie who doesn't understand the nature of the business and users ... (Systems Manager, Aerospace Industry, England).

This particular manager admits his analysts exercise autonomy but then shocked at this realisation, emphasises that it is a politically dangerous game, one best played by experienced professionals. Another systems manager was even more forthright:

> There is little in this organisation that hasn't got systems department written all over it ... our values embodied within it (Systems Manager, Regional Energy Utility, Wales).

Another manager argued that:

> We are neither autonomous nor subordinate ... we work for the good of the company (Systems Manager, Large Private Utility, Wales).

Obviously, determinations of what is good for the company are pretty unproblematic to this particular manager. In conversations I had with him, determinations of what is 'good for the company' unsurprisingly coincided with what he believed was good for 'systems' i.e. the systems department and 'business generally'.

One systems consultant highlighted the ways in which analysts' autonomy can be exercised:

> [Often analysts and their managers will] bring down a big book and say [to the user] that's what you asked for, now sign off for it ... and the user in all likelihood will take one look at this book, probably won't understand it -.too much to read- and say, "Fuck this! The DP guy seemed a reasonable enough sort of bloke. I'm sure he knows what he's about" and sign off for the system ... It happens often .. it's manipulation (IT Consultant, Major UK Consultancy).

In effect, the analyst hides his ulterior motives within the design process behind the 'technical jargon' and excessive documentation procedures that accompany the design process. One particular analyst indicated that:

> We are in a position to influence choice of hardware and software ... We don't like to see good hardware and software being rejected out of hand by users ... We can be stubborn here ... I can't compromise on this ... We use all our powers of persuasion to make users see sense (Systems Analyst, Major Public Service Institution, Derbyshire).

Analysts exercise autonomy but they sought to assure me they exercised it with discretion and in the 'interests of the system' and 'company', the two usually being conflated. Analysts and systems managers would, when pressed, also pride themselves on the mature exercise of this autonomy:

> Experience brings with it both judgement and organisational jurisprudence ... It's important to know how to exercise judgement ... and to know when to push and when to back off (Systems Manager, Regional Energy Utility, Wales).
>
> A good analyst knows ... instinctively, how to exercise discretion ... Who to talk to and what he needs to know to build the system ... This is exercise of autonomy ... but it's exercised with maturity and in the interests of the system (Systems Analyst, Financial Services Institution, Scotland).

That so many analysts justified this exercise of autonomy, in terms of protecting or securing systems/company interests, indicates the unease which they felt over the issue of autonomy. To openly admit one exercises autonomy, is not something analysts readily do. However, when they do, they often justify this in terms of defending system interests, broadly defined. Open recognition that systems design may, after all, involve compromise in which analysts exercise arbitrary authority rather than acting as dutiful 'servants', risks alienating them from users and undermining their professional credibility and sense of identity as 'servants' to the user functions.

Not only do analysts exercise varying degrees of autonomy within the design process *vis-à-vis* users, but also *vis-à-vis* their own managers and with regard to the exercise of their own labour power:

> Obviously, in one sense, my work is structured. I am accountable to Andy (the systems manager) and most large scale work takes place within project teams in which I would also be accountable to particular project managers ... Andy also emphasises that we are accountable to users [managers] ... There are also a variety of techniques available to management to monitor your productivity and quality of your work ... But even so, I still largely plan my own working day ... I decide, usually, which user or group of users I need to speak with ... I decide what might be the most appropriate development scenarios to suggest, what software or hardware to use ... So yes, I do have a lot of responsibility and autonomy over my own work (Systems Analyst, Large Private Utility, Wales).
>
> Roger (the systems manager) is pretty laid back ... He just leaves us to get on with it ... There are no really solid rules you have to adhere to ... I think you need the autonomy to be reflexive and adaptable to changing work loads, tasks and users (Systems Analyst, Automotive Components Manufacturer, Wales).
>
> If you increase control over analysts and over how they go about doing their work, if you try to straight-jacket this work and make it procedure and rule bound, you risk losing creativity and adaptability (Senior Systems Analyst, Financial Institution, Scotland).

Analysts argue, like many professionals, that autonomy and discretion are important parts of their job, in the sense that they need 'freedom' to be 'creative' and 'reflexive'.

This open recognition of the need for exercise of autonomy contrasts sharply with their unwillingness to recognise the implications of the exercise of that autonomy over others' work. By and large they failed to communicate to me the connection between this exercise of autonomy within their own work as a powerful precondition for their exercise of autonomy over others' work. This is one reason why some systems managers and senior users are trying to more tightly circumscribe the nature of analysts work.

Professionalism and Status

Professions, according to 'trait theory', are defined in terms of a set of in-built qualities and characteristics (Johnson 1972). Thus, Millerson (1964) offers an account of a 'model' profession as one exhibiting some, or preferably all, of the following characteristics: skill based on theoretical knowledge, an extensive period of education, the theme of public service and altruism, the existence of a code of conduct or ethics, insistence upon professional freedom to regulate itself and the testing of the competence of members before admission to the professions.

Attempts on the part of the BCS, IEE and NCC to secure professional status for systems analysts follow similar functionalist paths with emphasis upon examination, education, standardisation of tools and techniques, ethical codes of conduct and self-accreditation and regulation of membership.

A central argument of the IEE (1989, 1992), the BCS (1986, 1989) and NCC (1987) is that they are contributing to the establishment of a professional structure for systems analysis practice. The BCS 'Performance Standards Extract' (1986) is designed with four purposes in mind:

> 1) To provide a set of guidelines that will assist both employers and employees to define training needs and also to create career development structures for all types of information staff.
> 2) To provide an industry-wide broad standard set of definitions for the jobs that are carried out within information technology, independent of any equipment or application bias.
> 3) To provide a set of performance and training/development yardsticks against which, those who seek to become professionally qualified within the industry, can be measured in terms of experience gained and training received.
> 4) To, similarly, provide a set of performance yardsticks which can be used by those already qualified professionally within the industry, to maintain an independently validated record of skill and knowledge updating (1986:1).

The document thus attempts to strengthen the professionalisation of the industry by delineating job categories and suggesting relevant qualifications, experience and rewards. It constitutes an attempt to impose a structure and standardised practices on a new, dynamic, fluid and very non-standardised industry - one which is said by some to involve a heterogeneous and disparate group of people, high labour turnover, uncoordinated training schemes, competing tools, methodologies and techniques, a cavalier work culture, shoddy work, lack of standards, quality and continuity, systems failure, late delivery and lack of back-up and maintenance (Cornes 1988, Eason 1987, Martin 1984, Wainright & Francis 1984, Willcocks & Mason 1987). The Manpower Services Commission, the IT Skills Agency, the Engineering Training Board, the Computer

Services Industry Training Council, the Department of Trade and Industry and others (Meissner 1986, Jenkins 1986, Buckroyd & Cornford 1988, EDP Analyser 1976) have all supported moves towards standardisation of the industry. A number of hard and software houses and IT trade journals have also stressed that professionalism is vital to getting user and public acceptance and legitimacy of the IT industry.

However, there are several problems with the BCS approach. First, less than half of the systems analysts I interviewed were members of the BCS which simply did not have the recognition in systems analysts eyes that accrues to the engineering institutes. Second, many employers are so desperate to recruit systems staff that entry into the industry was and still is relatively easy. Third, many systems managers and IT directors I interviewed were not keen on recruiting graduates because they were perceived as demanding higher salaries, were more likely to leave an organisation in search of career promotion, and did not always have sufficient business experience. Fourth, the plethora of competing tools, techniques and changing hardware and software, mitigate against the establishment of professionalism in terms of a definable, recognised and fixed body of practice, methods and ethics. Fifth, routes of entry into analysis are varied, many companies prefer in-house end users to be trained up in the systems culture to do analysis, others prefer school leavers who are bright and show initiative. This diversity of entry is exacerbated by the fact that there is no professional control over entry, training or standards. Sixth, moves towards user orientated design and utilisation of project team approaches, external consultants and industry/business experts further weakens attempts to establish professional status. Seventh, many within the industry and outside it, argue that the occupation has a poor image. Systems analysts have been characterised and parodied along a variety of spectrums from 'techies' to 'yuppies'. Likewise the 'me now' culture, as one systems manager described younger graduate analysts, is detrimental to public and user acceptance of analysts as professionals. Finally, attempts on the part of some managers and organisations to deskill and routinise analysts work, either through the introduction of specific tools and techniques, or through tighter project management (Friedman 1989), further undermines professionalism.

Professional work is generally deemed to have a service element either to some notion of 'common good' (for example, in education or health), to an individual client or within an organisation (i.e. the provision of a staff service to line management). Typically, moves within the IT industry towards professionalisation are closely tied to perceptions of systems departments and IS staff servicing user needs. Yet the reality is that user needs may be shaped, moulded and even decided by systems departments. This can pose dilemmas for some systems staff:

> We are supposed to serve the user function ... That's what we are here for ... But what happens if the user request is not compatible with that of the rest of the organisation? ... Do we still serve them? (Systems Analyst, Large Private Utility, Wales).
>
> We are a service department and frankly we are perceived as servants ... Loyal and trusted servants ... (interviewee smiles knowingly) .. and servants *must* serve (Systems Manager, Automotive Components Manufacturer, Wales).
>
> Our proper title is 'Systems Department' ... We tend to be out on a limb. I don't think you can serve two masters. And if your boss is part of the function you are supporting, as one of many, it can be unhealthy ... We come under admin. yet we design systems for admin. and everyone else ... look I'll be honest with you (tape recorder turned off) ... We are answerable to a department that may know fuck

> all about IT, I'm not saying that is the case but it could be ... Why should we come under someone else's department? ... We get put over a barrel ... I don't see why we shouldn't have a head of IT because were not just DP any more where you have a stack of punch cards and a couple of magnetic tapes under your arms ... We are now part of mainstream business [and] we're central to business success ... But we are not duly recognised politically or rewarded commensurably, in terms of status (Systems Manager, Aerospace Industry, England).

Clearly, systems analysts and systems managers were expressing ambivalent feelings. On the one hand they recognised, in line with the policies of their own professional bodies, that they were a service function and sought to draw their status and esteem from this by arguing that they were 'trusted' and 'loyal servants' to the business function. It was also argued that they should be duly accorded status and respect. On the other hand, they tended to display hostility and even contempt towards the very users they were there to serve acknowledging, with wry smiles and gestures, that they were not really absorbed into this client-servant function. More importantly, there was general consensus that it was they, as analysts, who were in the best position to know what their political masters should want and how they should act.

Professions often present themselves as ethical and altruistic occupations in which the central relationship of trust between client and professional is supposed to rest on the belief that professionals will act in the clients' interest. Yet, as a number of systems analysts demonstrated, they may either act directly in their own interest, however perceived; or more commonly, they will attempt to persuade the users into accepting a system which complies with the needs of 'the system' as defined by the analysts and IS department. Difficulties of establishing ethical codes of practice are further complicated by the fact that there is a variety of different hardware and software vendors trying to promote their particular packages and by the fact that general business interests may be put before those of specific user interests:

> In this industry there is dealing from top to bottom [and] people are making lots of money selling systems that may be totally inappropriate ... There are hundreds of different vendors ... They pressure us [and] they pressure users directly [where] bribes and persuasion all play their part ... In this context, it's not easy to be ethical ... Is a consultant from CPL being ethical if he advises a user function to utilise his hardware or software? ... Or is he putting his own interests first? (Systems Manager, Large Private Utility, Wales).

One consultant I argued that the IT industry may have a glossier image than engineering but that it has also attracted unsavoury people who do nothing for the industry's professional image:

> The greed of people in this industry is unbelievable ... £45-50,000 salaries for good analysts at the business end is nothing extraordinary ... They are young, very materialistic and don't give a damn about culture, only their Porsches, and quite frankly couldn't give much of a damn about the implications of their designs, so long as they keep getting contracts ... Such is the state of the market, it is easy to get contracts (Senior IT Consultant, Major UK Consultancy).

Another systems manager pointed to the professional contradiction of interest that can arise between users and systems staff:

> On the one hand we are there to serve users [and] to enable them to carry out their functions ... We do this and we build up close relations with different users

> [and] they begin to trust you and respect you and that's a good basis for sound analysis ... It makes it easier ... But sometimes you have to report various users - users who might be resistant, obstructive or not prepared to accept your proposals ... It's betrayal in one sense ... I try and instil in my analysts a sense of balance and perspective [and] the difference between a good and bad analyst is this sense of perspective, knowing when the limit's reached and then doing something about it ... diplomatically (Systems Manager, US Multi-national Manufacturer, Scotland).

Hughes (1975) and Esland (1980) argue that it is a characteristic feature of professions that they guard their monopoly of knowledge very closely and seek to 'mystify' this knowledge, to make it appear that while long training and experience are necessary and that there are indefinable skills that only members of the profession possess or even understand. Certainly many systems analysts and systems managers I spoke to couched their claims to professional status in more esoteric language than that being advocated by the BCS and IEE which are seeking to define systems analysts' work, in terms of a tool kit like CASE - an approach which was met with alarm on the part of some systems analysts who argued it would reduce them to 'the status of technicians' and 'discredit' them in managerial circles.[8]

Software production is a crucial area which capital has, so far, been relatively unable to commodify and tightly control.

> Having bought the labour of programs and systems analysts, as a commodity on the market, capital is, at the moment, unable to raise the real subordination of this labour to capital to anything like the level it has achieved in hardware production processes ... The relatively high cost of software production is put down by management to the fact that designing and writing programs is a labour-intensive process. This means that the essential tasks in the production of software are largely executed under the control of labour, instead of being

> executed under the control of capital ... In software production the handicraft relationship between labour and its product exists to the point where a programmer frequently talks of a program he is working on as 'my program' ... The weapon capital is using [to gain control of the software labour process] is the division of labour (Duncan 1981: 184-185).

Jamous and Peloille (1970) have argued that where a high degree of indeterminacy exists in the work of a profession where tasks are variable and non-rationalised, so people who control them are likely to enjoy high status. Whilst analysts readily acknowledged that tasks were variable and that they had high status, in terms of the overall labour market, and particularly relative to engineers (whom many analysts perceived as getting a raw deal) they nonetheless felt that they did not always have the status they deserved:

> I have a lot of responsibility ... I've helped design systems central to this firm's profitability ... Yet in terms of pay, office, invitations to meetings and a whole variety of perks that my equivalents in accounts get ... I'm not really acknowledged (Systems Analyst, Regional Power Generating Company, Wales).

Likewise, being part of a service function to some larger and more powerful user department was not without its problems:

> Being a service function doesn't always help ... Some users like to wield the big stick at us sometimes and it can get you down (Systems Analyst, Large Private Utility, Wales).

More generally, lack of status could make the analysts job more difficult both in terms of being a subordinate colleague to possibly more senior and powerful user managers, and in terms of being perceived by users as primarily a service or technical function:

> The benefit of letting someone like myself come into a company is that I would never let any manager, no matter who he was, prevent me from doing my analysis ... There are user managers who are very territorial ... who try and oppose the work of systems analysts ... and quite frankly, I feel for the poor sods because I know that most SAs don't have much power vis-à-vis user managers ... If these managers tried to oppose me, shit would fly. If I was brought in at executive level I would have them sacked (Senior IT Consultant, Major UK Consultancy).

> Who is the systems guy? ... He's probably someone in his twenties up through the programming route, nervous and insecure in management circles. If he's 'in house' he's probably terrorised by fire breathing user managers with far more power than him ... This is not the kind of change agent to ensure that any bullshit is cleared so that effective business systems can be developed ... You need power to be a professional ... but in all honesty, look who the system analysts are, as a social and political group, and tell me, are they honestly in a position to get such status? ... The growth in IT undermines professional credibility - tossers and wankers are doing this job. Any self respecting dynamic go getter with guts and flair will be in at the management and hard guts end (Senior Consultant and IT Director, Major UK Consultancy).

However, not all systems analysts are in their twenties (the majority in my study were in their thirties and forties) and, most were remarkably resilient, persuasive and tactical in their dealings with users.

> There are ways to persuade and cajole users, no matter how rude or abrasive they may be ... I have co-opted other analysts to sit with me in such situations, or I have discussed the issues with particular key users over lunch in the pub - which I've paid for and ... which I've found relaxes them. Analysts, particularly where they know there's going to be some real system jolts as a result of their analysis ... can become very pally and chatty ... offering nice packages to users, software for the kids ... taking up the cudgel for them in meetings in which they are present ... There's a lot you can do ... It requires experience though (Systems Analyst, Large Private Utility, Wales).

Likewise, not all systems departments are 'out on a limb'. In some organisations IT is part of the central business function and duly recognised with corporate IT directorships:

> Within this corporation IT has recently been recognised as a prime business function. I can put it stronger than this: we *are* the business. Banking would collapse without us. Corporate management have had to recognise this [and] I sit on the most senior decision making boards of the bank. Nothing happens without me knowing about it. Over the years I have got my fingers in every pie and I have my eye on all users ... What is more, this position is strengthening daily, as is the position of systems generally ... Nothing gets done without us ... More and more strategic functions come under my control (IT Director, Major High Street Bank, London).

Not all user managers likewise breathe fire. Some were amazingly docile and ill at ease in the company of systems analysts, not just because they often stood in awe of the analysts technical knowledge - which the analyst often 'dressed up' - but, more importantly, because they were concerned to show their departments in good light and to be seen as co-operative, willing exponents of 'modernisation' - particularly if they felt big brother might be watching:

> Generally, I find user managers once they get to know you and once you have calmed their fears ... respect your technical skills and understanding of their problems. As you work through the analysis with them and sweat out the issues ... and get down to the details of hardware and software and who's going to be doing what - a process which can last weeks or even months ... you become involved, so caught up in the process of change that you become very close ... Some of the hardest, rudest, toughest bastards I worked for ... are the ones who keep calling me back ... It's like knowing a good mechanic or doctor : you're never satisfied with any other ... You build up deep bonds and understanding over the years (Systems Analyst, Heavy Electrical Engineering Company, Scotland).
>
> There aren't many users in this company that aren't aware of the state of the market and that we must modernise working practices to stay competitive ... It's

> become part and parcel of everyday language ... It's kind of taken for granted [and] not many users can resist this kind of culture ... (Systems Analyst, Japanese Electronics Manufacturer, Wales).

Whilst information technology and information technologists have become more central to business, I found that they were still, generally, well removed from the formal *loci* of power and organisationally subordinate to user functions, lacking in status, rewards and prestige bestowed. This can cause serious tensions as I have indicated above and as the systems manager below captures:

> I don't think we will ever have the status or size to stand on equal terms with the larger user functions ... But they know that we know it is our finger not theirs which is on the organisation's pulse. We get the general perspective they get the particular perspective. The general can always ridicule the particular in meetings (Systems Manager, Regional Power Generating Company, Wales).

The loyal servant, true to his master to the last but wishing, if only every now and then, that his master would give him due recognition and praise for the services he renders.

Summary

Like engineers, systems analysts are not merely the passive recipients of some dominant ideology of 'capital interest' which regulates design and informs its rationale. Rather, they actively interpret through their own experience, values and methods what that interest is or ought, to be. Unlike engineers, analysts were rather uncritical of the 'free market' credo. It seems ironic that notions of technical beauty or rationality so often happen to equate with business requirements.

However, like engineers, analysts often find their work compromised, for example, on the altar of cost benefit analysis. Likewise, either through personal predisposition or because of the features of analysts' culture (for example, systems theory) they may either be affronted by requests for particular designs or feel that they cannot deliver those designs because to do so would be to compromise some core values. Likewise, discussion of analysts' autonomy within the design process opened up a clear dichotomy. On the one hand they felt obliged to reiterate that they were a 'service function' to user departments, whilst on the other hand, they indicated that perhaps users were not always in the best position to know what was best for them. This caused obvious tensions and brought into question issues concerning their legitimate role and function within the design process, that they may be working to implement management drives for tighter control. At the same time they, too, are subject to managerial controls through project supervision, the application of standardised methods and, above all, the reification of the user function within systems discourses.

One of the central arguments of my thesis is that analysts actively interpret through a distinctive culture and set of values what is 'best' for the organisation. However, their particular interpretation of 'system interest' does not always coincide with that of users. Indeed, there is an alarming rate of user dissatisfaction and system failure in the West (Forester 1989, Jones 1989, Rada 1994). One is obliged to ask whether analysts themselves are, at least partially, to blame for this. Consequently, in the chapter below I focus upon systems analysts` practice and demonstrate the ways in which analysts own design activity, values and culture exacerbate the tendency towards user dissatisfaction and system failure.

The Software Bottleneck:

Democracy, Design and the Analyst

Introduction

This chapter focuses upon the software bottleneck within systems development. Through an examination of this bottleneck and the proposed solutions to it I open up the work of systems analysts more fully and demonstrate the ways in which their own particular culture and practice conditions definitions of system success or failure. Importantly, I also demonstrate how that culture and practice reinforces particular systems design approaches and undermines others.

Various solutions have been proposed for overcoming the software bottleneck by both practitioners and writers in the field. These solutions range from attempts to automate and systematise large aspects of the analysis and design procedure - utilising a mix of technology and refined methods - to more open recognition of the need to instil in the analyst as 'change agent' (Bennett & Kemble 1991) the necessary social, political and organisational skills. For many years there have been increasing calls for more user involvement in the analysis and design process (Dickson & Simmons 1970, Guthrie 1972, DeBrabander & Edstrom 1977, Lucas 1978). Greater user involvement in this process is often presented, in itself, as a panacea. I demonstrate, however, that the definitions of 'user' that analysts use are intentionally vague and that user involvement in design is consequently both limited and not without its problems.

Finally, I examine the contradictions between private ownership of the means of production and democratic systems design. I argue that 'systems' perspectives to design are inherently uncritical of the dominant power relations within organisations. Consequently, systems analysts tend to be victim of their own `systems' perspective. On the one hand they may seek to 'socialise' the process of design so as to tap into employee experience and creativity and to win employee consent to change. On the other hand they can do so only within the constraints set by the dominant set of property relations and configurations of power which flow from them.

The Software Bottleneck

One of the key challenges for systems designers is to be able to map accurately increasingly complex user environments in software. Evidence suggests that there is a 'software bottleneck' both in terms of systems developers' inability to deliver the systems that users require or expect, late delivery of systems, and poor software performance (Boehm 1987, Jacobson & Bennet 1993, Gibbs 1994, Rada 1994). Within the IT industry, it is acknowledged that there is a need for better systems:

> Traditional data processing methods of implementing systems have led to many human problems and have not often been successful (Eason 1987:22).

Wainwright and Francis (1984), the Economist Informatics Unit (1988) and Price Waterhouse (1989) all document the high rate of systems failure pointing out that data processing strategies are matched to business strategies in only one in ten installations. A survey of 288 UK firms indicated that over two thirds of them did not expect their IT systems to be delivered on time (PAGG 1989). Schware (1989) reports that one quarter of large software projects are never completed and of the remainder, the average application is delivered over one year late and at double the original budget. Gibb (1994) argues that software failure in America is still alarmingly high. Rada (1994) argues that the gap between the demand for new complex software systems and their actual delivery in a form which meets user expectations is rapidly widening. The difficulties of bridging this gap have been described as the software crisis, a crisis which has worsened as systems have become larger, more complex and moved 'real time' (Rada 1994, Gibbs 1994).

There have been numerous prominent examples of system failure. Quintas (1991) documents how American Airlines lost $50 million as a result of software errors in its flight booking system. In Britain the Department of Social Security's computerisation programme will cost an estimated £1,749 million, instead of £713 million, when it is completed in 1999. Estimates for telecommunications increased by 714%, programming by 215% and running costs by 136%; and the Ministry also admitted that it had given a £4.75 million contract to computer consultants for work which it did not need to undertake (Hencke 1989).

Quintas argues that

> Cerebral and interpersonal activities remain key elements of software development. Software is the bridge which spans the gap between the binary logic of the machine and the altogether more unpredictable world with which the system user has to deal. This process is so complex that some observers maintain that software development will always be labour intensive and prone to error (1991:360).

The push for radical change within the software development process, for example, the Alvey Programme into the development of software engineering tools, indicates an attempt to break with what Hoare characterises as an 'arcane and error prone craft activity' (1982:4) and the desire to establish that activity in terms of an 'engineering discipline'. My own research and that of others (e.g. Peleaz 1988, Friedman 1989, Blum 1994) suggests that modelling the social in the technological is a far more complex, labour intensive and political process than seems to be believed by many advocates of engineering solutions to the problems of systems design.

My research indicates that there are a number of reasons which are understood to be responsible for the limited quality of systems design:

> 1) The separation of the analyst from the end user, and the centralised nature of DP departments.
>
> 2) Lack of business acumen on the part of computer systems personnel and of business managers on the potential of IT.
>
> 3) The inertia in existing systems, i.e. sheer number of applications running COBOL and similar systems which not only require considerable maintenance but inhibit decentralisation.
>
> 4) The failure to establish, correctly, the needs of users - because of a failure to apply either the appropriate tools and techniques (e.g. 4GLs, CASE, SSADM, etc.) or an appropriate 'soft' approach.

Unsurprisingly, the bulk of literature on systems design is overtly prescriptive, concerned with advancing particular tools and techniques - ranging from user co-option to project teams, use of prototyping, elaborate requirements capture software etc. - the bulk of this literature does not, however, address the broader social, political and theoretical issues involved in systems design. Nowhere is this more readily observed than in the literature and daily systems discourse, which reduces a complex social division of labour into an essentially dualist model: systems staff and the rest of the world, i.e. 'users'. On the basis of this dualist model, trade journals, software and hardware vendors and many systems practitioners offer their particular solutions to analysis and design problems . Solutions which usually embrace one or more of the following panaceas:

1) Greater user involvement in the analysis and design process, either through utilisation of software engineering tools, or closer collaboration between user and analyst, possibly through decentralising DP out to user departments.

2) Utilisation of more rigorous analysis and design methodologies like SSADM or LSDM, likewise more rigorous applications of CASE tools, formal methods and expert systems.

3) Automation of as much of programming and analyst work as possible.

4) Better management of analysis and design process with due regard being given to the cultural, political, social and organisational factors that can impinge on design.

5) Equipment of analysts with not only technical but also organisational and business skills.

6) Letting users design their own system and facilitate this by supplying them with appropriate tools and expertise and by moving away from mainframe systems to more distributed and networked mini and micro computing facilities.

7) Improving management's awareness of IT, particularly in relation to establishing importance of IT to a firm's corporate objectives, and develop IT training on the part of management and users.

A useful way to present the range of these solutions is to consider a spectrum from 'hard' to 'soft' (Checkland 1981). The 'hard' approach emphasises the use of mathematical modelling techniques, CASE tools and automation of as much as possible of the analysis and design process. By contrast the 'soft' approach emphasises the social context, allowing human actors in the problem situation, greater freedom of choice and more autonomy over the design process. Willcocks and Mason (1987) suggest that the 'soft' approach is necessary for the analysis of organisations involving large associations of people pursuing individual and collective goals that are, not necessarily, the same and may even be incompatible - where decision making can be compromised and risky and where objectives are changeable, ill-defined and complex.

While there is a shift from hard modelling techniques towards those in which the user enjoys a closer relationship to the process of systems development (Meissner 1986, Uzzi 1995, Blum 1994, Long *etal* 1995) user involvement *per se* does not necessarily signify an abandonment or weakening of 'hard' systems' philosophy. CASE and structured methods generally can facilitate user involvement whilst at the same time tightening managerial control over users, for example through imposing rigorous methods whilst at the same time reinforcing management conceptions of the unreliability of labour - i.e. perceiving it as dysfunctional to the 'system'(Bjerknes *et al* 1987).

The notion of 'users' that either approach adopts is, however, vague. Most of the literature on systems design is weak in defining the 'user'. The user is usually conceptualised in terms of managers of user departments. Consequently, the variety and complexity of labour within different departments is obscured and over-simplified - brought into debates begrudgingly and within the parameters defined by the manager and systems analyst. Usually in terms of 'how best can we harness direct users' skills' and 'experience to meet the objectives we have decided upon', and 'how best can we incorporate users into the system', or gain 'their acceptance of the system', so as to minimise conflict and disruption (Tan 1994, Carroll 1994, Watson *et al* 1994). Systems analysts and systems managers had varying understandings of the term 'user' - some referred to only senior management, others user departments, others to supervisors and a few to actual operatives. Interestingly, whilst in daily practice experienced systems analysts and systems managers would recognise the diversity of users and user interests, in terms of defining the software bottleneck and proposed solutions to it, they habitually dropped the vocabulary of complexity to replace it by the simpler dualist model of the analyst-user.

To have a rigorous definition of users, one which recognises their diversity and heterogeneity and the real possibility that interests of users may not coincide - not even within the same department or function - and that clashes of interest and antagonism can arise between users (for example, antagonisms rooted in different objective class relations) would be to shatter the systemic model which analysts use to rationalise their own work and to justify particular system choices. The systemic model is explicitly functionalist. To recognise possible sources of irreconcilable interest is not only to recognise such interests as dysfunctional and in need of elimination, more importantly, it is to overburden and increase the complexity of the analysts' task: which is one reason why the boundaries of a system are often tightly determined[1]. This was precisely the argument of one systems manager I interviewed:

> From the point of view of practical design, you can't have your analysts spending all their energies trying to discuss and incorporate all the possible permutations of user interest within the system ... The poor sod would become so enmeshed in eliciting requirements that he would never be able to define the parameters of the system ... If you define these parameters, in advance you don't need to talk to every level of user ... or get embroiled in the political debates (Systems Manager, Major Public Service Utility Wales).

Ironically, analysts are praised for having good organisational skills and yet it would appear that there is a limit to just how sophisticated their organisational understanding need be. Several analysts, particularly senior analysts, indicated a relatively rich understanding of user relations and of specific organisational politics and power. However, even they habitually dropped their earlier more sophisticated models when it came down to practical design. For example, while they would convey to me the need to listen to users and `build in' user requirements into the system, in practice they listened to only certain groups of user and incorporated only certain perspectives - those which were `manageable' and `met with systems approval'. One possible explanation for this is that they must advance the 'system' interest as defined by either senior management, user managers or themselves. Often, to advance the system interest they must drop their earlier more complex models which recognised user diversity and possible sources of antagonism and friction. In effect they content themselves with recognising that whilst the system is not ideal from *all* user perspectives it is up to personnel to sort out the problems.

Another reason why analysts perennially use a one dimensional model of the user has to do with both the service nature of information systems departments and the commodification of software packages, tools and techniques used for modelling and analysing the user environment. Historically, IT has played a secondary role, a supporting role to business functions. IT has thus grown up in a close relationship to user managers and heads of business functions. System origination, funding of projects and the setting of requirements is thus a process influenced historically by business users - that is, by management. He who pays the piper calls the tune:

> Obviously in an ideal world it would be nice to speak to Joe down on the shop floor and maybe once in a while design something just the way he would like it ... But people like Joe don't pull the purse strings and don't have any muscle ... It's sad but true ... Really we are very close, possibly too close, to management of the business function [and] sometimes it obscures clarity (Senior Systems Analyst, Defence Sector Electronics Contractor, Scotland).

Likewise, the commodification of software packages, tools and techniques used for modelling and analysing user environments, reinforces a systemic, functionalist, view of the user. Paleaz (1990) highlights how software production is becoming increasingly commodified. Major manufacturers and vendors servicing the IT industry and business seek to sell their own particular solutions to potential buyers. Manufacturers of software and business purchasers share a discourse and products are sold on their capacity to tighten control, increase productivity, quality and efficiency (CASE Strategies 1989, Cybernetics and Systems Analysis 1992, Handbook of Systems Management 1993). Often the very architecture is such that it not so much inhibits open recognition of user diversity and heterogeneity, but channels the analyst down a particular information gathering path which has, as its premise and conclusion, pre-set objectives. This is how one Senior Consultant described one particular proprietary methodology:

> The logic behind the methodology [and] its architecture ... is such that it suggests to the analyst, particularly the younger and more inexperienced, what the logical procedures of analysis should be and what weight you give to each particular phase of the analysis programme ... This particular methodology, like most on the market nowadays ... puts a lot of emphasis on the front end [and] on setting the parameters and defining the requirements of the system ... It emphasises that each process of the analysis needs to be validated and checked off with the appropriate personnel, for example user managers ... If at this initial stage he or she feels the parameters and requirements don't comply with what they want the analyst is cautioned and told to proceed differently ... It's a form of control ... and inbuilt into the tool (Senior Consultant, International Consultancy).

I turn now to five different approaches to systems analysis and design. My objective in examining these approaches is to demonstrate the issues practising analysts face when designing systems and in particular to determine which approach analysts favour and why. These approaches represent a broad cross spectrum of proposed solutions to the software bottleneck. All aim to improve the process of systems analysis and design. With the exception of the fifth approach, the collective resource approach, such improvement is generally defined in terms which include conventional notions of organisational efficiency, i.e. profitability. All advocate or prescribe a particular solution or practice. All are concerned with greater user access or involvement though this is defined in a variety of ways, and from a range of political perspectives - from technicist efficiency through humanist commitment to the dignity of work, to notions of the interests of workers and management being in conflict - some of these approaches are methodologies while others are concerned with tools or techniques; some are concerned with both of these.

Automate and Decentralise

This is the solution advanced by Martin (1984), who argues that the software bottleneck has created a backlog of some two to four years in application software which has been caused by the growth in demand for systems, the increasingly competitive environment, and the increasingly complex nature of systems as they have moved from batch, to on-line and now decision support. He advocates better analysis and design, and better software. Traditional systems analysis and design, Martin argues, is too costly, too slow, and too cumbersome. For example, Martin argues that the stage of writing lengthy and complex specification documents should be eliminated:

> The last act of a dying organisation is often to write an all encompassing rule book ... One methodology sold and used in many installations consists of 32 two inch thick binders which spell out in detail how to create requirements and specifications. They expand the methods of the 1970s, which are so inadequate, into a bureaucracy which is immensely time-consuming, entirely non-rigorous, prevents automation of code generation and is unchangeable (1984: 36).

Systems are needed quickly, more quickly than such an approach allows. As he sees it, the prevailing life cycle, which so dogs the automation of systems development, grew up before the advent of:

1) Non-procedural languages

2) Techniques that generate program code automatically

3) Computable specification languages

4) Rigorous verification techniques

5) On line graphic tools for design

6) Formal data modelling tools

7) Strategic design planning techniques

8) Information engineering

9) Languages for rapid prototyping

10) Languages for end users

11) Distributed processing and mini computers

12) The information centre concept.

Martin advocates the automation of both analysis and programming.

> Programmers and analysts have automated many people's jobs but are remarkably reluctant to automate their own (1984: 19).

He refers to a range of ways in which programming needs to be automated: small query facilities, complex query and update languages, report generators, graphics languages, decision support tools, application generators, computable specification languages, parameterised application packages and very high level programming languages.

Systems analysts can use tools that generate code automatically. Even highly complex systems, Martin argues, can be generated from specifications; and end users can themselves create systems.

He argues that techniques are now available to generate mathematically provable error-free code:

> This methodology is so powerful that it needs to be regarded as a major new technology for creating systems which in a sense makes obsolete earlier structured techniques (1984: 145).

He recommends that DP departments buy high order software (HOS) to eliminate errors, omissions and inconsistencies.

Finally, to optimise the use of these tools and techniques, the information centre is crucial:

> [The] growth of information centres is the most vigorous new trend in DP management. An information centre is a facility designed to encourage, train and support end users who use computers directly, generating reports or creating applications. At the same time, the information centre should manage user-driven

> computing so as to avoid its many potential problems ... The overriding objective of information centre management is to greatly speed up the creating of applications that end users require. The queue for conventional development, with its long applications backlog, is bypassed (1984: 101).

The information centre enables the management of end users and it should be 'a natural division of labour between the end-users and DP staff'(1984: 104).

> Often the centre is staffed by people trained as systems analysts. Their job changes fundamentally. They no longer write program specifications, draw data flow diagrams, and so on. They act more as consultants, listening to the end-users' problems, solving them, determining the user's needs for information, encouraging, training, and selling ideas to end users (1984: 117).

Martin's approach is staunchly supported by a number of writers on systems analysis methodology and tools and techniques (Beynon-Davies 1989, Bennet & Kemble 1991, Occelli 1993, Hardgrave & Wilson 1994, Finkelstein 1994) and a number of teachers of systems analysis (Lane 1989). Whilst a number of those I interviewed argued that Martin's approach was a useful attempt to address some of the major problems contributing to the software bottleneck, the majority were sceptical of the claims Martin was making for particular tools and techniques:

> People like James Martin are trying to bring home the need for programmers and analysts to be aware of the tools and techniques available to help them in their task. But there is no way these tools or techniques will replace the programmer-analyst function. (Systems Analyst, Large Private Utility, Wales).
>
> A lot of Martin's arguments are pie in the sky. His advocacy of tools such as 4GLs, downplays their limitations. Vision dreams and reality don't always tie up and so we make an adjustment. And the adjustment in 4GLs is that, yes, within

> certain limited criteria, they are useful. But they haven't been developed to a level of sophistication which will yet allow them to duplicate the expert. (Director, Micro Computer Unit, Wales).

Fenton (1993) argues that the claims advanced by various proponents of software engineering for a 'technical fix' to the software bottleneck are impressive but rarely live up to expectations. The main problem with Martin's approach is that he focuses on DP practice and applies hard techniques in that area. Thus, he falls into a technicist trap, for the problem in system design may lie elsewhere - in industrial relations, worker attitudes, user co-operation, status, skill requirements, or the priority attached by management to training, to name but a few. A number of interviewees argued that Martin's methods are no better than others at modelling these social variables and that he over-estimates the capability of the tools, which do not solve the central problems of systems analysis, design and efficiency. The tools, techniques and information centres will only facilitate the quicker and more accurate translation of perceived requirements into concrete systems: they do not remove the ambiguity surrounding the various interpretations of what the requirements might be, what unwritten or unspoken rules or knowledge may exist about an operation, or how the firm's market position may change due to competition, or other unforeseen circumstances.

> Martin and everybody else say they have got the solution to this problem, be it tighter structured methodologies or better developed tools, techniques and practices. But they haven't. If you can't standardise the end user, you can't standardise the service industry to support it, no matter how hard you try ... If COBOL is manual and RPG3 is manual with overdrive, then 4GLs are automatic ... and as everyone knows, automatics are heavy on fuel and if you take your hands off the wheel you still crash (Director, Software Consultancy, Wales).

> You can't develop a sophisticated system or write a program for it on the basis of 4GLs and other CASE tools ... The plethora of tools, techniques and systems we have today is because of the discontinuity of system design ... If you get modelling right, you don't need a plethora of other technologies. Systems are far more bounded than Martin thinks ... In my opinion Martin is creating obstacles or difficulties which do not exist (Senior Systems Analyst, Major Private Utility, Wales).

However complex the mathematics, it cannot eliminate errors in the concept of what a program is trying to do it can only correct errors in meeting the specification. As many interviewees said, you cannot program for every contingency. Any IT system will have repercussions on the organisational environment, not all of which are possible to predict or contain (Newman & Rosenberg 1985). In other words, the systems analyst has to map not only the social world, at the point when the system is introduced, but also the changes which may take place in the future as a consequence of, for example, changes in markets or labour relations (Ernest-Jones 1989a, 1989b, Caulkin 1989, Uzzi 1995, Blum 1994). It would seem quite impossible for anyone to foresee all of these, nor could any tools or techniques encompass all such variables and, in this sense, successful systems analysis will always be limited or relative[2].

Another criticism of Martin is of his claims for CASE tools and for prototyping tools in particular. Martin (1984) and Hardgrave and Wilson (1994) see software engineering and prototyping tools in particular as the solution to the software bottleneck. A number of analysts in my study used prototyping software to sit down and create design scenarios with users. However, they argued that these do not replace the 'front end' skills of the analyst i.e.

the setting up of requirements, terms of reference and boundaries of the system. Whilst useful in enabling analysts to work with users to produce workable prototypes they do not replace the organisational and communication skills of the analyst at the critical stages of extracting information and communicating needs and objectives. The code they generate was also seen to be less efficient (i.e. more costly in terms of speed and/or space) than manually produced codes (Goyal 1993).

One respondent explained his rejection of Martin's approach at length:

> I don't think it at all true that either programmer or systems analysts functions are being automated by new technology and new structured techniques. There is a dearth of good data modellers and no amount of CASE tools will actually teach a person to sit down and sort out entities and relationships ... A good CASE tool and methodology can go a long way to focusing the effort of the programmer and analyst, and can partially automate certain parts, like doing Third Normal Form ... Application generators are very good at automating things like extract and print. They will take 80% of programming off your hands, but remember the other half of the 80 : 20 rule, 80% of the volume takes 20% of the time, so the remaining 20% of the volume still takes 80% of the time. Things like all your protocols, interfaces, and complex algebra still have to be designed and written into the system and all have to be hand coded, no machine as yet will do all that for you. 4GLs only do 80% of the simple programming functions and consequently have only limited use in simple designs like data processing. Their use in developing sophisticated systems like the front-end of a guided missile system is non-existent ... At the front end there is nothing that can automate the setting up of the requirements specification. It is down to the business analyst to be able to actually sort out what it is that people need, setting the terms of reference, setting the boundaries, extracting the information and communicating needs and objectives, along with drawing up the data model, etc.. All this is very manual at the moment and I can't realistically see how the functions can be automated ... There is a limit to what the techniques and CASE tools allow you to do despite Martin's assertions to the contrary (Senior Consultant, Major UK Systems and Methodology Consultancy, Bristol).

It might be that systems analysts and their managers oppose Martin's approach out of some sense of self-interest. Most saw structured methods and CASE tools as useful within defined parameters, but as no substitute for the skills and experience of the systems analyst:

> It is all well and good giving end users the means to generate their own systems. But only when your mainframe systems are intact and your major business systems and databases are up and running, designed by the systems department ... Only then can you talk of allowing end users to manipulate his own database, write his own reports, possibly create smaller databases that he can manipulate or download on to a PC ... Quite frankly, we prefer to keep IT in our hands by design ... We had a classic case here in the early '80s when various departments were out buying turnkey systems, the end result was a ... balls-up, a mess of unintegrated systems and partial ... solutions. (Systems Manager, Major Private Utility, Wales).

Martin portrays those staffing the information centre as pioneers of new technology and technique, liberated unselfish servants of the organisation, whilst those staffing the traditional DP departments are perceived as backward-looking and reactionary, putting their own limited interests first. This model does not square with my findings, that one cannot make such clear cut and arbitrary pronunciations. Some of the most far-reaching, successful and advanced systems I have seen were developed within traditional centralised systems departments. Similarly, the use of many of the latest CASE tools and user-orientated languages are to be found within many traditional centralised systems departments. There was general recognition amongst those I interviewed, that although it was vital to get user involvement in systems design, the information centre concept was not the ideal medium for achieving it:

> Users know their own job best ... Users also differ enormously, some may be up to date with the latest IT developments [and] others may have just progressed to the pen ... If users are designing systems they are not doing what they are paid to do which is their job ... And if they are designing systems without a centralised IT facility and strategy you are asking for disaster ... What relation will the information officer from Martin's centre have to the user? ... If he or she is close, it can get incestuous and user interests can be put before organisational interests ... If the officer is young, inexperienced or lacking organisational muscle they will get stamped upon by more powerful user managers ... that's the reality ... That's why we need centralised DP (IT Director, Major Multi-national Bank, London).

Martin's approach and the shift towards more rigorous application of structured methods, tools and techniques is represented in the growth of 'software engineering' solutions to systems design. Software engineering is not only perceived by many as the solution to the software bottleneck (Finkelstein 1994) but is growing in importance as a design discipline (Bennet & Kemble 1991) and in its influence upon the education and training of systems analysts. Programmes like Alvey shape or construct a particular discourse and world view amongst the design community. Good design becomes design that can be rigorously checked, codified, controlled and reproduced in different institutional contexts. This is the dream of many within the software engineering community. However, as a number of writers within the field note, despite the plethora of tools and techniques and increasingly sophisticated modelling and prototyping software, not only is take up of these techniques by practising analysts low but the gap between the demand for new complex software systems and their delivery is widening (Rada 1995, Fenton 1993, Gibbs 1994, Goyal 1993).

Socio-Technical Systems Design

The socio-technical approach to system design has informed a range of systems analysis methodologies in Britain, Europe and Scandinavia. Developed by the Tavistock Institute and in accord with the Tavistock philosophy, it is concerned with questions of psychology, motivation, personal enrichment and values; and focuses on the organisation of work groups. With an emphasis on consensus and the common interest of various parties within an organisation, it constitutes the theoretical underpinnings of a variety of participative design methodologies. The essence of socio-technical philosophy is that systems should not be considered as solely technical systems to which workers must adapt, nor as purely human systems in which the human aspects alone dominate. The argument is that systems should be designed as integrated wholes, consisting of both social and technical elements to optimise technical systems, human systems must be harnessed. Under the Tavistock socio-technical approach, decisions about how work is carried out are taken by the individual and work group rather than supervisor.

The socio-technical approach, thus, has much in common with soft systems approaches and participatory design methods, (Willcocks & Mason 1987, Mumford 1984, Eason 1987, Hirscheim 1985, Tapscott 1982, Carter 1989). It is prescriptive and does not raise fundamental questions about the organisation of work. Most soft systems theory is some variant of the socio-technical approach. The leading proponent of the application of the socio-technical systems approach in Britain is Enid Mumford (1972, 1981, 1983, 1987). Mumford is concerned that human factors should be taken into account in systems design. She refers to herself as having

> played a proselytising role in trying to make technologists and systems designers aware of the poor fit between technological solutions and socio-technical problem requirements (1987: 9).
>
> Socio-technical design has clear ethical principles associated with it. This is, to increase the ability of the individual to participate in decision-taking and ... to exercise a degree of control over the immediate work environment ... In addition, through recognising the interaction of technology and social organisation and the need to try and optimise the behaviour of both of these, it increases productivity and provides the opportunity for individual learning and the development of multi-skills (1987: 67).

Bjorn-Anderson and Hedberg (1983) work from a similar perspective: they advocate user involvement in system design for three reasons, one of which is:

> Because organisations ought to respect human dignity and basic human rights, all members should have a right to participate in decisions about changes that are likely to affect them (1988: 135).

In contrast with such an approach, Mumford reports finding systems generally designed with technical factors at the forefront. She sets out to establish the extent to which a rational/technical ethic influences the design of computer systems (1983: 8). She starts with the hypothesis that:

> Industry, commerce and government were not getting clerical computer systems which were consciously designed to increase job satisfaction because the values which influence system designers are not of a kind which motive them to do this (1983: 4).

Her focus is on the value systems of the analyst and the mismatch of these to the user. Her analytical framework draws on Talcott Parsons' pattern variables 'to provide a logical framework for examining values and needs in our research situation' (1983: 27) and she defines job satisfaction by drawing on Parsons' notion of 'needs disposition' and 'role expectations'.

She argues that there is a realisation - though she does not substantiate this - that Tayloristic methods are no longer suitable; we are moving towards 'shared decision taking and industrial democracy' (1983: 2).

> Today most industrialised countries are concerned with improving the quality of working life for their employees (1983: 1).

In accord with the Tavistock philosophy, her concern is with increased user participation and satisfaction within a framework of improved business efficiency. In the same vein, Bjorn-Anderson and Hedberg's (1988) other two reasons for involving users in system design are that:

1) This makes the system more realistic and reduces resistance
2) The user probably knows the job best.

'Effective Technical and Human Implementation of Computer Based Systems' (ETHICS) is Mumford's system design methodology. This has three distinct characteristics:

1) a high level of user involvement
2) an increase in user job satisfaction as a specific system objective
3) an equal emphasis on good organisational design and good technical design.

She argues that ETHICS is the answer to poorly designed computer systems.

There are however, a number of problems with Mumford's approach. First, Mumford assumes that moves on the part of certain employers towards more autonomous forms of working and multi-flexibility signify some kind of qualitative transformation of capitalism as it enters down a new road of industrial democracy and concern for the quality of life of its employees. Such analysis abstracts these changes from the broader socio-political climate which has been characterised by recession, high unemployment, anti-trade union legislation, monetarist policies, increased part-time and temporary working, and, often, concerted attempts on the part of employers to tighten control over labour, be it through new forms of internal policing, such as quality teams, or through reassertion of more Tayloristic forms of management (Wood 1989, Hyman 1989, Brodsky 1994, McLoughlin & Gourlay 1994, Thompson 1995).

Second, participative design in the context of capitalist social relations of production may actually generate new problems, for example bringing underlying grievances to the surface which cannot then be resolved, opening up decision making and power distributions within firms, heightening possible antagonisms of interest between management and workers, or undermining the legitimacy of shop stewards and official trade union representatives (Wilmott 1988, Thompson 1995, McLoughlin & Gourlay 1994, Marsh 1993).

Third, Mumford's case studies are of the office and public sector which leaves one wondering about their broader applicability: would management in more highly capitalised sectors be as prepared to involve users? The culture, social relations of work and production processes within the office can be regarded as atypical and possibly more amenable to limited 'participative' design changes.

Finally, Mumford's methodology operates in the context of an 'efficiency' specification which subordinates worker representatives to the consultant's and management's agenda. More importantly the design team itself is highly unequal: you cannot by-pass existing authority and command structures which ensure employee deference to management simply by introducing a participative design methodology. Many employees will feel uneasy about commenting upon or criticising management suggestions and will not want to be seen to be standing in the way of managerial objectives. This was brought home vividly in one of my case studies where analysts, consultants and managers had opted for an 'open' and 'participative' approach to design, similar to that of Mumford's. Despite attempts by consultants and management to put employees at ease, employee deference to management was high. Sitting round the table, I could sense that many of the secretaries and users from the department under study were tense, nervous and ill at ease. In discussions afterwards, many voiced their fears that management would ask their opinion and that they were frightened to voice their feelings through fear of either appearing ignorant or possible management recrimination. Obviously, not all employees may be so intimidated. Nonetheless, despite managerial attempts to empower workers and encourage their participation in design and change, most of my interviewees, whether users, union officers or systems analysts, recognised that fear and distrust of managerial objectives in times of high unemployment, changing organisational cultures and anti-trade union legislation - does little to boost employee confidence in participatory schemes (Thompson *et al* 1994, Snape 1994, Gall 1994, Grant 1994, Brodsky 1994, Marsh 1993).

Only one of my interviewees had heard of Mumford's methodology:

> Concerning user-designed systems, I have read Mumford's work and spoken to her personally, and regard her arguments as gibberish. Mumford is a little do-gooder but her systems won't work ... Trade unions are the biggest brake on technological progress there is and Mumford wants to involve them in the design process. It is management's job to tell trade unions what to do. (IT Consultant, Multi-national Hardware and Software Manufacture).

The point about this statement is not that Mumford is denigrated, but that, like many interviewees, he sees user issues as management's problem. Such a perspective was displayed most clearly by systems analysts working on relatively 'hard' systems for heavy industries and with relatively manual operatives.

> It doesn't make good management sense to get systems analysts to speak to shop floor operatives, it could cause a whole load of industrial relations problems ... It's not up to you to convince the workforce of the validity of the system, that is the manager's task ... As far as I am concerned, there is no human engineering involved in the design of the system, apart from ergonomics and colour choice, etc.. We do not get involved with issues such as 'do we want to strengthen or weaken certain departments?'. We work in terms of business efficiency. What problems arise in terms of human relations from our systems is not really our concern ... Management is there to manage and it doesn't make good management sense to get systems analysts to speak to shop floor operatives. We are in the business of providing management with the necessary information and control over production to carry out their function ... You can't afford to get involved with what motivates people at work ... The fact that there is a human being at the end of the technology is irrelevant. It sounds callous but we are talking and operating in terms of business efficiency. (Director, Industrial Engineering and Consultancy Firm, S. Wales).
>
> Recession and recent trade union legislation leads to a greater acceptance of IT on the part of the workforce. We feel a twinge of conscience when we go in to design knowing the workers won't be there in six months time (Systems Analyst, Aerospace Industry, England).

Whilst some interviewees were more sensitive than others to user issues, many users and analysts alike expressed an overwhelming, unstated, assumption that systems analysts were in the business of 'efficiency', and that user issues were management's concern. Such an approach clearly circumscribes the utility of Mumford's approach.

User Centred Design

Eason provides us with another form of socio-technical analysis. He argues that although many new design methods are ostensibly more user-centred, they do not have the methods to deal with users. Eason, then, like others, identifies the problem of inadequate systems as the lack of suitable tools and techniques, and prescribes his favoured method. Eason distinguishes five design methods:

1) Traditional DP design
2) Structured design methods
3) Participative design methods
4) Local technician developed systems
5) End-user developed systems.

He argues that any one method on its own is only a part of what is needed and that in relation to some of these methods there are neither the techniques nor the expertise. Eason's proposals are essentially threefold: first, a user-centred strategy to get user considerations embedded in the system design process. Second, techniques to achieve this which can be used within existing design methodologies. (In other words, he provides a tool kit rather than a methodology.) Third, he proposes both a top-down and bottom-up approach, to ensure both co-ordination and the meeting of personal needs. Eason advocates the use of particular (user-centred) techniques at particular stages of the design process:

Design stage	User-centred Techniques
1. Feasibility	Analysis of socio-technical options Cost benefit assessment Team composition and strategy
2. Requirements specification	Organisational and task analysis Job design and organisational change User specification of technical system
3. Selection, design, evaluation	Usability design and testing Prototype evaluation

4. Implementation, support and evolution	Customisation Workstation and environmental design User support and system evolution

Clearly, all of the difficulties associated with the socio-technical approach apply to Eason's work. In addition, Eason assumes the homogeneity of users and that it is not problematic who users are. More importantly, he assumes that it is practicable to balance the interests of senior managers with operatives, and of individuals with technical efficiency. Like Martin, he makes a list of approaches but he does not say who is to choose which approach is taken, or who is going to ensure its 'neutrality' will it be a systems analyst with his or her own preferences, working within a brief of management? He does not say how user needs are to be met nor what to do if they are in conflict. The advantages of a technical system cannot merely be weighed because they may accrue to, or affect, different people who may have conflicting interests. He does not discuss the differential power of those participating in systems design. Finally, he identifies application generators and CASE tools as promising developments for user-centred design, but these can be employed to Taylorise work, rather than democratise it. In other words, he fails to address some fundamental questions, the answers to which constitute the underpinnings of his prescription.

Politically Contingent Design

Willcocks and Mason (1987, 1992) argue that to exploit IT, one has to understand its social, political and organisational context. Their approach is to integrate the system development process with notions of organisational behaviour. They argue that the systems analyst can react in several ways to designing a computer-based system:

> One is to adopt the hard systems approach in the belief that it will still produce the best result in the end. A second approach is to design human activity out of the system, or at least reduce it to the minimum possible, given the technology and finance available. A third approach is to under-characterise the human being's relationship to the technology as that of an isolated user, subject only to biological limitations. Thus ergonomics and human factors engineering brought into systems design. A fourth approach, the one followed here, is for those responsible for computer systems projects to integrate much broader human factors into the work of analysis, design and implementation (1987: 8).

They are concerned that the hard systems approach still holds so much sway at a time when more complex human-based systems are being developed. Their advocacy is not of a particular methodology, but of a more humanistic, soft approach. They argue that human factors should be taken into account in the achievement of business or organisational objectives. Their perspective on organisational structures and the system design process is what they term a 'political contingencies' approach: organisations are made up of various 'stakeholders' with competing interests; clashes between them can be resolved by negotiation, and by managers of change being aware of the delicacy and complexity of issue and choices, and by consciously managing the politics of computerisation.

Their argument - that human factors should be taken into account in the achievement of business objectives - is dependent on decoupling the organisation from a macro analysis. Whilst they accept that not all 'stakeholders' have equal power, or capacity to influence decisions or have their views heard, they do not explore the basis of this unequal power. Implicit in their approach is that stakeholders' different interests can be resolved by awareness and negotiation, and in this sense their approach offers an essentially *status quo* model of power: the organisation is presented as neutral, or technical, albeit embodying contest.

> Those responsible for computerisation need to become aware of other people's perspectives, but also need to adopt an appropriate perspective on technological change, the one most closely approximating to the pattern of power relationships and how the specific organisation functions (1987: 23).

This pluralist approach pervades their work, e.g. in their discussion of 'human resource planning for IT':

> Personnel management is concerned with managing conflicts and tensions that result from trying to use the efforts of human beings who all wish to make their own use of the organisation they join (1987: 43).

Willcocks and Mason argue that:

> Many of the problems of employee conflicts and sub-optimal systems running during or after implementation could be avoided by better human resource planning, more employee participation, going back as far as the design stage, and deeper

> consideration of the industrial relations' implications of decisions over systems design and how computers will be applied (1987: 156).

However, such analysis underplays the historical particularities of the environment within which UK organisations operate, i.e. recession, rationalisation, anti-union legislation, high unemployment and reassertion of managerial prerogative. Given this context, as Murray argues:

> One wonders what power employees are to mobilise to give them a degree of control over new systems. This is particularly so for women employees, who so often bear the brunt of the worst effects of technological change. There is scant evidence in the UK, or elsewhere for that matter, to suggest that a sufficiently enlightened managerial class will tackle, let along positively resolve, issues of this nature (1989: 294).

It is a strength of Willcocks and Mason's approach that they bring the organisation into the picture, but they seem to be aiming to harness social or political factors within the organisational context to achieve the best possible system. They are selling a philosophy for managing change, and one which is idealist and pluralist in that it is premised on the capacity of systems analysts to step outside their own interests, perspectives and methodologies as well as those of the employers they are working for.

The Collective Resource Approach

A variant of the socio-technical approach is the collective resource perspective. In Scandinavia the socio-technical approach held sway until recently, when it became apparent to trade unions that it was failing to change the nature of worker influence over the design process (Ryner 1994, Thompson, Wallace & Sederblad 1994). The Swedish labour movement argue that:

> In its development projects the Swedish Confederation of Employers stressed the individual in a form which complicated collective solutions and the possibilities available to the trade union movement (1987: 24).

The socio-technical approach came to be regarded as anti-trade union and anti-democratic by the majority of Scandinavian trade unions (Bjerknes 1987, Ryner 1994). Traditional participative approaches were seen as insufficient for the following reasons:

1) The appointed project group participants are often not trade union representatives
2) They have no real means of exerting power on the project group
3) There is thus the danger of union representatives becoming integrated in the employer's decision making process
4) The language, attitudes, philosophy and values of management's technical and organisational design experts has a tendency to spread
5) Trade union experts are then sometimes offered an expert position, and in this way the union loses access to information which its representative acquired whilst on the project
6) Union representatives are sometimes unable to comment on alternatives, so have to approve developments without having had a chance to explore alternatives
7) The gain to the union for giving management access to shop floor information is unclear and

> 8) Trade union participation is too often a management strategy to make it easier to implement planned change 1987: 40).

It was, then, precisely the failure of the socio-technical approach which stimulated the development of an alternative approach for participation, work organisation and democracy: the collective resources approach. Sandberg (1979) developed a critique of the ideology of the dominant systems design approaches in Scandinavia. He found that new technology did not always deskill, that management sometimes proposed more collective forms of work organisation than Taylorism, and that workers sometimes gained from the introduction of new technology.

Bjerknes proposes an analysis which identifies the processes which:

> are important for understanding opportunities and constraints to democratic and skill enhancing design and use of computer-based systems and tools (1987: 36).

He discusses four processes which constitute his premises. First, capital accumulation, or the generation of profit, is the basic driving force of changes in the labour process. In the long run changes that are contradictory to this interest are unlikely to occur. Second, the intensification of work and use of new technology are two basic strategies for capital accumulation. However, when really new technology is introduced it may imply increased skill requirements, when those with experience of the technology are sparse. Third, direct control and responsible autonomy are complementary strategies for capital accumulation.

Opposition from workers to a Tayloristic division of labour may mean high production costs and the relative profitability of alternatives; also, Taylorism leads to a loss of the skills of a workforce. 'Responsible autonomy' strategies (Friedman 1977, 1984) are an opportunity for trade unions to improve working conditions, and, at the same time, a threat - in that they may lead to competition between workers, and to control remaining with management (Arthur 1994, Grant 1994, McLoughlin & Gourlay 1994). The outcome of tendencies to rationalisation, however, is contested rather than determined. Finally, class struggle is an important aspect of the systems design process.

The collective resource approach seeks to go beyond the limits of the participatory approaches of Mumford and other proponents of the socio-technical school, involving trade unions in the design and use of IT systems.

Bjerknes argues that the process of system design must be seen as a part of the broader organisational development process, which he conceives in terms broader than those of traditional organisation theory, in that it encompasses a trade union response and looks at system design in terms of labour process theory. System design is conceived in terms of constituting the division of labour between conception and execution.

Advocates of the collective resource approach argue for new trade union initiatives which focus employee attention on the design and content of work rather than distribution issues i.e. demarcations, skills, pay etc. Clearly, the latter is the area in which trade unions have traditionally been involved, whilst their demands and strategies in relation to the former are only vaguely formulated (Sandberg 1979, Thompson, Wallace & Sederblad 1994)).

Trade union accumulation of knowledge is seen as the central prerequisite for trade union participation in the management design process.

> The most important prerequisite for trade union participation in management's design process is a parallel and independent process of accumulation of knowledge on the part of the union (Bjerknes 1987: 40).

Such participation has included the negotiation of local data agreements, the appointment of data shop stewards, the formation of investigative groups by union clubs, and the arrangement by unions of courses on influencing the design and use of computer systems.

Clearly, Scandinavia differs from Europe in that the historical development of business has occurred on the basis of labour shortage, trade union strength and heavy state regulation leading to the development of what Ryner (1994) calls a 'moral economy' in which workers are in a prime position to negotiate change and become involved in the design process. This contrasts markedly with the conditions experienced in the UK (Thompson, Wallace & Sederblad 1994, Marsh 1993) which raises questions about the applicability and viability of the collective resource approach elsewhere.

The collective resource approach offers a model for independent trade union participation in management project groups. However, the model is limited in its ability to allow local unions to generate their own knowledge base in new areas or to extend their technical competence and knowledge of systems design processes. Where are unions to get the resources to fund their own independent knowledge base? Likewise, the model cannot be generalised, in a context where inter-union competition for contracts is high and individual unions are desperate to maintain and secure membership at almost any price (i.e. with 'no strike' and 'sweetheart deals') and prepared to abrogate basic trade union principles, such as the right to strike and collective solidarity. What serious resistance to or involvement in management projects can they be expected to have?

The collective resource approach to systems design is grounded in reformist conceptions of capitalism and the state. Bjerknes argues that:

> In a democratic society the state should play an important role in supporting research and development of a more democratic technology ... and give opportunities for domestic markets for realistic size or at least initial production of this kind of technology (1987: 48).

It fails to acknowledge the bourgeois nature of the democratic state (Milliband 1973) and the rationality of the capitalist system with its concern not with the production of use-values - democratically arrived at or not - but with the production of exchange-value. Further, there is no evidence that either the state or corporate management are about to weaken their grip over the design process via inclusion of worker representatives and openly democratic systems procedures (Brodsky 1994, Gamble 1994, Thompson 1995). Even in the favourable labour market conditions in Scandinavia, the degree of participation in the design process is highly proscribed which must bring into question the applicability of the collective resource approach as a medium for securing active worker involvement in the design process.

The Project Team Approach

In my research I found that systems analysis practice was based on none of the above approaches. The most common approach I found was that of the project team. Friedman (1989) referred to the developing practices of organising DP staff on a team basis. The project team was seen, by the majority of analysts and systems managers I interviewed, as the best means of tackling systems design in that it utilised the skills of a variety of people - end user, systems analyst, project manager, and senior manager alike. It was argued that it could thereby overcome the problem of the general inability of any one person or tool to embody the full range of required knowledge and skill:

> The [project teams] that are able to perform the best have teams of complimentary skills and the total team knowledge can be harnessed and, in my opinion, this is the best way to design systems because you cannot incorporate that wealth of expertise and knowledge in either one person or in a piece of expert software (Director, Micro Computing Centre, Wales).

Both systems analysts and systems managers seem convinced that:

> so long as you pick the right project team encompassing the right personnel from the right departments and with the right skills, you overcome the system design problems (Senior Analyst and Project Manager, Large Private Utility, Wales).

However, in practice, project teams differed enormously, in both terms of skills and knowledge prevalent, and in terms of choice of 'right' project team members. Project teams also differed in terms of size and resources and this was argued to have an important impact upon the quality of systems developed:

> For several years now we have been tightening belts in this company across the board including systems ... The project we are currently working on ... in my opinion, requires greater user involvement and more time spent talking to users at the coal face ... We would also benefit from a couple of experts in ergonomics ... but financial and time constraints won't allow it ... Obviously the system is going to get compromised as a result (Systems Manager, Defence Sector, Electronics Contractor, Scotland).

Budgetary constraints are but one of many factors that can influence the working of the project team. Project teams are often steered or led by one or two powerful individuals who, either through position or knowledge, or both, are capable of capturing the ideological high ground and orchestrating the debate. This was brought home forcefully in one particular project I studied at a major private utility. The systems manager and a couple of senior users - managers in accounts and customer services were keen to see the introduction of hand-held terminals which would allow both meter readers and workmen in the field to key in vital information on bills, repairs needed, work in progress, tools and equipment needed, etc. However, a senior user manager and several line managers in customer services and maintenance opposed the idea on the ground it would give either too much autonomy to the workforce over data entry, or that it would mean job loss and deskilling, or that the terminals simply would not withstand the abuse they were bound to get out in the field. The systems manager and senior systems analyst went to copious lengths to ensure that the project team which would look into the feasibility of hand-held terminals would find in their favour:

> Dave has decided to call in a couple of top knobs from the military and from the manufacturer to prove that these terminals can withstand anything our workforce can throw at them ... It will be a surprise ... I have also been spending a large proportion of my time considering the possible job savings in terms of by-passing typists and operators in customer services and maintenance, stores, etc. ... We can make some major headway [and] we had the foresight to let Frank in accounts and a couple of senior managers know about this ... We've also been pushing the sexiness of terminals and how this will fit in with our new corporate image ... It just looks nicer [and] more efficient if a man is standing there reading your meter, or ordering work via a hand-held terminal, rather than scruffy pieces of pencil and paper ... We are also bringing down some staff from East Midlands who have run the scheme successfully for the past 12 months ... Whatever happens ... we will be doing all we can to ensure our interests are represented strongly, both at next week's meeting and within the project team (Senior Systems Analyst, Large Private Utility, Wales).

Not only were the systems manager and senior analyst orchestrating the proposed systems development but they were also manipulating the actual composition of the project team:

> Obviously we want key players in at the start on our side ... I see this as an important project for the department. I'll be putting my best analysts and programmers into this and using my contacts and resources to bring in reputable consultants and expertise ... I've already spent a number of weeks trying to butter up some pretty heavy user managers but I'm confident that Frank and me can pull it off ... One concern is possible job losses or redeployment [and] it's going to be a thorn we are going to have to deal with ... Hopefully, the unions won't get up-wind of this [and] we shall certainly try to downplay losses [by] emphasising redeployment and security of jobs created (Systems Manager, Large Private Utility, Wales).

The systems manager argued that unions would not be 'troubled' with the earlier stages of the design proposals and they were certainly excluded from negotiations during my two month involvement in this particular project. Likewise, the seniority of staff that the systems manager had mustered to his side for the first 'open meeting' was quite remarkable and obviously flustered the 'opposition'. The first meeting of the project team took place in the systems department in a well appointed and plush office; a variety of drinks and refreshments were available. The initial meeting was light-hearted and a video was used to woo 'the opposition', as the senior systems analyst referred to them. The video mixed cartoon characters and real life characters to demonstrate old and new practices, the video was produced by the retailer of the equipment and tailored for this particular company. Most of the discussion afterwards was initiated by the systems manager, who insisted that all they were really there for today was to look at the technology and talk to the users and manufacturers of it. After the meeting, a lunch was laid on via private caterers. At lunch, the senior systems analyst explained the whole process to me:

> As you can see, we've gone to great lengths today to convince Clive and others [initially opposed to the new system] that this is the system we need ... Its not just a question of arguing the technology but relaxing the user ... reinforcing in him a sense that he is in good hands ... that we know what we're doing ... and that we are working with him ... Round the table today we had Tony and Allen, two of our best analysts and well respected in the company. We had senior consultants from TPK and CLM, we had management and sales reps from the equipment manufacturer, user managers from our sister sites, accounts, finance, customer services, Katherine and Angela who will be liaising with customer accounts and who are respected within the department, myself and Chris who will be managing the project ... It all

> went very well don't you think? (Senior Systems Analyst, Large Private Utility, Wales).

In practice then, the project teams are often, if not always, loaded as key personnel within the organisation, seek to ensure that their interests are represented. There was a spurious sense of democracy around the table with opinions being voiced quite openly and due respect being shown by relevant parties, but both the systems manager and senior analyst in the above example were concerned that not only should their proposals not be rejected by senior users but that direct users and particularly unions should not even be involved, at least, in the early stages. The overwhelming impression I was left with, was one of a well executed, neatly engineered exercise in manipulation, subterfuge and flattery.

Regarding the operation of the project team the systems manager stressed that the day to day functioning of the team would be the responsibility of the project manager. It was suggested that he may use SSADM as a project management tool, or at least part of it, because he was wanting to give it a try as part of an assessment of methodologies that the department were undertaking. Whilst the systems manager did not anticipate day to day involvement of all the users, he emphasised that his own staff would be working in close collaboration.

So is good systems design reducible to knowledge, experience and skills? Certainly the majority of systems analysts I interviewed believed so, apart, however, from two notable dissenters:

> It is naive to assume that the project team simply because it comprises suitably skilled and experienced personnel is, thereby, going to design good systems ... I've worked in project teams where we've had some of the best personnel and experience in the industry but still made a balls up ... Some things you just can't overcome or deal with adequately, like obstinate managers or an industrial relations dispute ... Successful systems can only be defined by management ... You can be involved in a project team which has made huge blunders and developed sub-optimal systems ... but still be regarded as successful because management liked it (Senior Systems Analyst, Major Pharmaceutical Manufacturer, Scotland).

Clearly, this analyst is alluding to the important fact that project team success is related to system success which, in turn, is going to be conditioned by prevailing notions of profitability and efficiency. The irony is that what may at one time have been thought a successful system, in terms of meeting these objectives, may, at another point in time, be seen as 'sub-optimal':

> I remember working on a project in the mid-seventies ... in which our aim was to automate as much as possible ... Nowadays we are realising the mistakes, in terms of lack of flexibility and sheer problems of maintenance ... Today, management are emphasising flexible systems ... When I look back we all congratulated ourselves when the project was completed ... [I think] what a bunch of white coated misfits we were then ... We wouldn't even be trusted to clean the floors if we took that attitude today (Systems Analyst, Large Electronics Company, Scotland).

Project team success is thus measured, amongst other things, against whether or not senior management and executive decision takers are happy with the outcomes. Project teams that deliver systems which do not meet, or undermine, corporate goals can expect severe wrath from senior managers and corporate directors:

> I remember working on a team several years ago in this company....we were toying with the idea of allowing employees in customer accounts greater freedom over information inputs into the system which was then done through extensive cards and paper filling.....Many of us believed that rather than eliminate employee involvement we would raise employee commitment and productivity by giving them a degree of discretion and decision making responsibilities which were previously held by supervisory grades......We thought we were doing a good job.....but soon as senior management got wind of the system they came down on us like a ton of bricks. We were all, individually, given severe bollockings and asked to explain what the hell we were playing at. The systems manager of the time was particularly shafted....he was told to disband the team .....and outside consultants were brought in (Senior Systems Analyst, Large Public Utility, Scotland).

I asked this particular analyst if that meant an end to project team autonomy within the company. His reply was instructive:

> It was not so much an ending of our discretion....I mean we didn't just become puppets of corporate management from that day on.....but we did learn...or at least most of us that we should keep designs to ourselves. We were too casual in the past...far too open. Too many individuals got wind of the system before we had the chance to put over a convincing package of arguments. Nowadays we play the cards close to our chest (Senior Systems Analyst, Large Public Utility, Scotland).

Rather than merely becoming the puppets of corporate management and forgoing all autonomy over design analysts learn to play the game. They ensure their interests are, at least in part, met through a variety of means including - keeping `the project team tight', utilising technical discourses to whitewash over recalcitrant users and managers and `subtly persuading' management that the system they are advancing is in the general interest of the organisation. In effect, they ensure design is kept, where possible, secretive. I found that project team composition was important. Invariably systems managers wanted `teams that were tight,' `knew the game' and were capable of manipulating others rather than being `manipulated by them'.

Discussion of tools and techniques designed to elicit greater user participation in design fail to acknowledge the political interests of project teams and in particular their essentially anti-democratic nature.

Democracy, Design and the Analyst

Marx (1981) argued that the development of the productive forces comes into conflict with the social relations of capitalist production as the further self expansion of capital manifests itself in a tendency to periodic crisis of overaccumulation and devalorisation.

Within the systems design process this antagonism, between the forces and relations of production, manifests itself in the form of a contradiction between, on the one hand, a companies need to develop technologies, techniques and practices capable of more accurately modelling the social world, so as to be better able to exploit it, and, on the other, the need to conserve surplus-value producing relations, that is, capitalist relations of exploitation.

In effect there is a tension between democracy and design within the capitalist mode of production. `Democracy stops at the office door and the factory gate' (Einhorn 1982: 5). The secretive and anti-democratic basis of power and decision taking within the systems design process results not only in management shutting out trade unions from participation, or trade unions, generally, accepting that design is management's 'prerogative'; but also ensures that practising systems analysts, generally, acquiesce in this anti-democratic process. This acquiescence is often unconsciously mediated and rationalised in terms of 'value-free' design criteria. This rationality is not merely the result of particular routes of entry and types of training systems analysts receive, nor reducible to their position within the division of labour but is also, a reflection of the wider ideological stranglehold bourgeois commodity relations have over designers. Accumulation appears a technical process, a rational process, the market the most 'efficient' and 'effective' allocator of resources and medium of motivation. I found that systems analysts, more so than engineers, invariably have no alternative design discourse to that of the free market and tended to be uncritical of that market.

The spread of IT across the economy as a whole and its use in increasingly complex and sophisticated user environments, has done little to weaken this ideological stranglehold. The increasing complexity of systems being modelled has pushed management and designers into seeking and eliciting greater user participation in the design process (Friedman 1989, Tan 1994, Edmonds *et al* 1994, Uzzi 1995), so as to be better able to map, model and modify the user environment. However, it needs to be remembered that a participative approach to design is not the same thing as democratic design. For example, Norman (1984) proposes that democratisation of system development should not pose a challenge to the structure and policies of the organisation. In similar fashion, a host of writers advocating user involvement in the design process and more 'open' systems design, do so but within narrow constraints. Thus, Nisenbaum (1994) emphasises user involvement in the design process but qualifies this by stating that the designer needs to be aware that users can be 'wayward', 'awkward' and need to be 'carefully managed'. As Williams argues:

> Democratisation of systems design is explicitly divorced from consideration of other areas of industrial democracy, and is counterpoised to politicisation (1987: 81).

None of the participatory user centred design strategies secure democratic participation of users in the design process (Bjerknes, *et al*, 1987). Indeed, structured systems design approaches actually inhibit democratisation of the process by structuring the problematic in a particular way:

> I would suggest, systems staff think systemically... [and] analysts tend to perceive the system as a higher organism with its own needs ... Design and users, where possible, are subordinated to these higher needs (Software Engineer, University).

> Structured methods have an architecture to them whose purpose is to ensure the analyst asks all the right questions so as to elicit the necessary information from users to build the system ... The architecture is also important in the way it suggests to analysts which questions are important and what users need to be asked. More than this, structured methods treat users as information sources ... as inputs ... They are inputs into the system ... the system is contained in embryonic form in the architecture of the methods ... It is the interests of the system as laid down in the methods which structures the problematic and subordinates both user and analyst to them ... I would suggest structured methods are not just perceived as best systems practice but are an attempt to impose a systems perspective on users and systems staff alike... to inculcate in them a particular world view in which ... the systems interest predominates ... This is a powerful world view because it appears universalistic ... whereas users can always be brought over the coals for being particularistic as can systems staff who fail to recognise the rules of the game. Like all rules structured methods reflect the interests of those that make them [and] there is nothing democratic in them although they appear democratic (Systems Manager, Health Service, Scotland).

Systems analysts approach design with relatively rigid conceptual models in which notions of systems interest are embedded in a discourse of technical and business rationality. Within this systems discourse, human labour constitutes an area of uncertainty, a possible source of system dysfunction and instability: `People are trouble, but machines obey' (The Engineer 1978: 24-25).

It appears that it seldom occurs to analysts' to question the validity of project origination by senior management. And also they do not readily question the origination of the project team or methodology deployed[3]. To question this would be to question the systems perspective which they hold and the rationale of their own labour within that process as deliverers and guardians of the 'system'. This was brought home, candidly, by one software engineer I interviewed, at length, over the issue of democracy and design:

> I would suggest ... analysts live in a culture which inhibits truly democratic participation of users or, indeed, truly democratic systems design ... The outward development of participative design technologies and techniques masks the inward attempts to secure control over users and ensure system efficiency. More importantly, analysts are only part of a broader team [and] they are often subordinate to, but increasingly part of management broadly defined ... in the sense they share the same goals and aspirations (Software Engineer, University).

What this engineer is alluding to is that systems analysts' work is part of a broader fundamental division between workers and management, with systems analysts carrying out the conceptual work necessary to subordinate workers interests to the goals and aspirations of management, albeit interpreted systemically. One systems analyst I interviewed highlighted the material practice ensuring analysts 'accepted' the dominant goals and aspirations of management.

> You are punished for designing systems with unnecessary bells and whistles [and] systems that do not deliver what management anticipated ... Too close an identification of interests with those of lower level users will be rewarded with lack of career progression, unrewarding projects, back end and routine analysis and a closing of senior user ranks ... which will prevent you working on prestige projects (Systems Analyst, Multi-national Electronics Company, Scotland).

Likewise, the development of prototyping and CASE tools fail to democratise the systems design. What they do is facilitate user involvement in the design process and, in this sense, make evident management's reliance on worker co-operation; but users are manipulated by the very architecture of these tools:

> CASE is theoretically democratic ... A set of tools and techniques aimed at facilitating the analysts in getting the user involved ... But the architecture of CASE is such that it structures the issues of systems definition in a particular way [and] the methodology [and] the software itself forecloses certain scenarios whilst suggesting others ... It also puts the analyst in a commanding position vis-à-vis the user ... as he is more likely to know the theoretical architecture behind the models ... Often I would suggest even the analyst is unaware of the way the tool structures the design (Software Engineer, University).

Advocates of structured approaches to design or of greater user involvement in design fail to recognise the ways in which the actual architecture of the tools and techniques used structure the problematic in a particular way. Sitting down with a user in front of a screen using prototyping software and asking the user what they would like may appear democratic. Initially, when I sat down with analysts and users utilising this technology and approach, it appeared to confirm much of the literature emphasising user-centred 'democratic' participation and the analyst's role as 'facilitator'. This was, however, not the case. The user did not always understand the broader parameters of the system - its overall objectives. Nor did they always know what was most suitable for themselves in terms of the system being proposed. Most importantly, both the analyst and the software structured the design problematic in a particular way:

> It's not a question of just giving the user everything he or she wants ... You can't just let a user loose at the screen and expect them to understand the systems objectives and the limitations as to what is practicable or possible ... The software structures the design down a particular path [and] it suggests to the user certain possibilities and options. It suggests where modifications may be useful and what they may possibly be ... it suggests but does not counter-suggest ... It advances a particular perspective [and] I guess I reinforce that perspective as I sit with the user ... (Systems Analyst, Large Public Utility, Derbyshire).

Another analyst was even more straightforward:

> User involvement is needed so long as it does not contradict the initial spec (Senior Systems Analyst, Large Public Utility, Derbyshire).

Participation is useful but some things are more sacred, namely, ensuring 'requirements' are met. But who is setting the requirements? One systems manager argued:

> Requirements are set by management ... either user managers, or corporate managers, or user managers and ourselves, or even just ourselves ... It depends upon the type of system [and] it's scale ... Large systems tend to be initiated by senior management who have some vague idea about what they want - usually on a line of cost savings and productivity gains ... We then discuss at a preliminary meeting how these broader requirements may be met and depending on the scope of system ... I may suggest who and who not to involve in the project ... (Systems Manager, Pharmaceutical Manufacturer, Scotland).

'Requirements' are invariably set by either managing directors, senior consultants, or senior user managers and systems managers. These requirements are defined in an undemocratic way but their realisation often requires detailed involvement of different types and levels of user, with the design taking place in an atmosphere emphasising co-operation, unity of purpose, and commonalty of interests of all concerned. Opposition where it is met, is often impersonal, and discussed in terms of dysfunctionality:

> It's important to get users involved ... This is not just politics but a matter of urgency if you are going to tap into their knowledge and understanding of their particular business ... but you have to appreciate which suggestions and information is functional to the system and which is dysfunctional (Systems Manager, Large Public Utility, Derbyshire).

Analysts often present a particular design and the methodologies they deploy in securing it as simply a 'technical' issue while downplaying the consequences of possible work re-organisation, regrading, deskilling or work intensification that may follow on from a particular approach and design. Ironically, many users I observed perceived the tools, techniques and methodology deployed by systems analysts in similar terms. Users did not readily question the assumptions built into either the approaches, or technologies, used for eliciting user-information and likewise, seldom realised the impact of particular hardware/software configurations until the project was well under way. This was particularly true of lower level users and union representatives who were generally kept in the dark and not exposed to the broader systems architecture and overall methodology. By regarding the technology and systems practice as neutral, Jungk argues:

> [We have] failed to recognise as anti-human, and consequently to oppose the effects of, values built into the apparatus, instruments and machines of their capitalist technological system. So machines have played the part of a Trojan Horse in their

> relation to the Labour Movement. Productivity becomes more important than fraternity. Discipline outweighs freedom. The product is in fact more important than the producer. (cited Levidow and Young 1981: 53).

A number of analysts admitted to me that they often dressed up their designs in technical jargon to push through particular interests. One software engineer stressed that this was not democratic:

> The practice of design and the medium with which we are working - IT - is high tech and obscure to many users and we know this ... You can present personal ideas via the technology [and] the technology makes these personal ideas appear technical because they are originating within the software ... In scenario software we can use windows and menus to allow users a degree of involvement - democracy if you like over the choice of what they would like to include ... But they are choosing from an options list set either by myself or the software manufacturer who share similar perspectives ... Obviously the system rigs their choice ... It's not democracy, I suppose, because it's rigged ... but then so is government ... You choose between a number of candidates none of whom you may like or whose policies you fully understand (Software Engineer, University).

Traditional design methods condition system designers' approaches to design. Reinforcing the dominance of dead labour machinery and technology, over living labour that is reinforcing the social power of capital over the working class. This takes the form of not only designing systems to eliminate human labour *per se*, but also to secure managerial control over its freedom and exercise of skill within the production process:

> It is not my job to enrich workers' lives or make their work more rewarding or satisfying ... Workers are there to work and management to manage [and] my function is to support management in that task ... Consequently, I do not

> recommend hardware and software or systems approaches which undermine that function (IT Consultant, Multi-national Hardware and Software Manufacturer).

Cooley (1981) cites the example of designers contemplating a robotic solution to the problem of tightening nuts on oil pipelines and scaffolding in the North Sea. The designers initially went for a robotic solution to eliminate human labour completely from the operation. However, they realised it was not that practical once they began to consider the programming complexities of getting a system to recognise which way a hexagon nut was about, and much less whether it had a barnacle or weed on it and then to select the correct spanner and apply the correct torque. More importantly, there was a whole area of 'experience' which the human operator had that could not be replicated in the software - the experience of visually knowing, without measuring, what diameter a nut and bolt are, and how much torque to apply without wringing it off and yet at the same time tightening it sufficiently that it will not come loose:

> This they can do without any 'scientific knowledge' such as torsional rigidity of the bolt or the shear strength of material, yet they will get it right repeatedly (Cooley 1981: 59).

As Polyani states: 'There are things we know but cannot tell' (cited Levidow & Young 1981: 59). It is this esoteric or 'tacit' knowledge and experience which traditional systems design approaches fail to recognise or build into their designs. One possible reason why management cannot readily tap into this esoteric world of experience and knowledge is that to do so would risk foregoing, to a large extent, its attempts to dictate the labour process and control labour power. Capital thus meets a barrier - that of its own surplus value producing relations. This barrier acts to inhibit management's capacity to further transform the labour process so as to secure further surplus-value within a particular branch of production.

There is, in short, a fundamental contradiction of interest between capitalism and democracy. For management to democratise the design process would be for them to risk foregoing surplus-value production and appropriation. This is not to say management do not develop strategies which seek to encourage worker involvement and participation in the design process, or that worker participation is, at times, advantageous from the point of view of surplus-value extraction; rather participation is not the same as democratisation - the participative exercises I observed were invariable exercises in manipulation. There is no indication whatsoever that either management or systems designers are about to openly democratise the design process. Indeed, far from IT being the harbinger of democracy, many corporate executives perceive an altogether different role:

> Information Technology is basically a technology of co-ordination and control of the labour force, the white collar workers, which Taylorian organisation does not cover (Franco de Benedetti, Managing Director, Olivetti, cited Levidow & Young 1981: 194).

At a very general and profound level the very class relations of capitalism impinge upon the democratic design and take up of skill enhancing and job enriching technologies. As one union official argued:

> Much as we would like to be involved in the design of technology and work organisation ... we are having to spend all our time bending over backwards to plead with employers to save and maintain jobs, terms and conditions ... in this climate our members first concern is the wage packet [and] issues of democracy and design at work which were coming to the fore in the 1960s and early 1970s, have been kicked in the head. We have never been further away from the recommendations of the Bullock Report (Regional Official, TGWU).

Interestingly, although there is a strong emphasis within systems design on 'soft' systems and more participative and democratic design processes there seems to be an accompanying emphasis on engineering and mathematical modelling of user environments (Blum 1994, Occelli 1993, Hardgreave & Wilson 1994). Equally, as Child and Tarbuck (1985), Legge (1989), and Willcocks and Mason (1987) argue, there is an increasing exclusion or marginalisation of personnel and human resource management specialists from the process of technological change.

Possibilities of Analysts Transcending Dominant Design Paradigms

Although analysts generally took an uncritical and unquestioning approach to design, sharing, by and large, managerial definitions of efficiency and rationality, there were, nonetheless, a number of possible sites of resistance to, and disruption of, this dominant model. In particular, I noted that a number of analysts felt that 'their' systems had been adversely compromised by managerial requirements - usually budgetary - or that analysts felt management had defined systems' requirements incorrectly. A number of analysts, particularly younger ones, were intimidated and threatened by more powerful senior user managers. In addition, systems managers, in some organisations, were attempting to tighten control of systems analyst labour via tighter project control and a variety of performance monitoring tools and this was seen, by some, as posing the possibility of deskilling or reducing status. A number of analysts also voiced concern over the adverse repercussions of their designs on users jobs and skills. A couple of analysts were also adamant that they were socialists and not at all impressed with 'monetarism' or the 'market'. However, none of these factors, either singularly or together, prompted any analyst I interviewed or observed to reject dominant systems approaches to design.

Examples of designers rejecting dominant systems approaches to design are rare. One such example, was the case of the Workers Corporate Plan at Lucas Aerospace. Cooley (1981) highlights how the interests of technologists and workers coincided at Lucas Aerospace where joint design co-operation between engineers and workers proved to be a politicising experience for both parties. As one designer quoted by Cooley discovered:

> Management is not a skill or craft or profession but a command relationship, a sort of bad habit which we have inherited from the army and the church (1981: 57).

A number of engineers in the Combine Committee highlighted that their work on socially useful products like telechiric devices or the 'hobcart' - a design to enable disabled children to move around more freely - were the 'most rewarding' experiences of their life. In short, they began to question the validity of their work at Lucas Aerospace and the 'negative' projects and technologies they had previously been involved in designing.

The work of the Combine Committee on socially useful products highlighted that the design methodology used in a 'socialist technology' would have to be radically different from that which applies in our current technology. As Cooley argues:

> At present ... highly qualified designers and technologists spend months drawing, stressing and analysing a prototype ... These design stages involve rarefied, complex mathematical procedures which are necessary mainly because, for commercial reasons, materials have to be exploited to the full. Both the materials and the systems of the products are designed just to perform a precisely defined function for a very short length of time before the product is rendered redundant (1981: 57).

Obviously, designers in different countries and different sectors, public or private, may have different degrees of leeway when it comes to designing democratically or considering issues of skill and worker satisfaction within a particular design. Factors like the nature of the market, government legislation, type of product, technology, and specific balance of class forces, etc., all play their part in conditioning the design process. Thus one systems manager I interviewed highlighted how, for him at least, it was preferable to work in the public as opposed to private sector because he did not particularly want to be involved in designing systems whose sole purpose was the enrichment of shareholders. However, he also recognised that even in the public sector design remits were tightening and that control and accountability were becoming key features inbuilt into many of the new operating systems:

> There was a time when you could approach a design in a more open ended way, for example, considering the needs of specific users and even suggesting to them needs which they might not have thought about ... Rather like, well, currently you are doing such and such but you could be doing it with bells and whistles attached or in a more rewarding way ... Nowadays even here things are tightening up as systems design becomes more subsumed under the accounting mentality to life[and]everything is to be costed to the last penny: no more bells and whistles or fancy frills on the systems ...then there is this insidious pressure from above for control ... for mindless, repetitive control and accountability of every last action of every last user ... Creativity in design and personal preference get subsumed under this accounting, cost cutting control mentality (Systems Manager, Health Service, Scotland).

One senior systems analyst I spoke to referred to the change in political climate and the way this has affected the 'quality' of the system design:

> In the seventies unions and shop stewards were pushing generally for improvements in the quality of working life[and]for a while this posed interesting possibilities for a minority of us in the profession who quite frankly would have liked to have built more qualitative systems. That is systems with more than one or two dimensions ... Too much systems design today is influenced by the new politics of control and costing [and] in many ways it is reflected in a newer breed of analyst [who are] more materialist and ruthless. I've been over to Norway and also to Germany and it seems to me that there, at least, they build more quality systems. Systems which do more than account and control ... systems which actual enrich employees lives and you know this makes design more rewarding and worthwhile ... It does to me at least (Senior Systems Analyst, Pharmaceutical Industry, Scotland).

Ironically, despite having developed more sophisticated methods for modelling the social in the technical, the systems design profession is, by and large, doing so merely to wed users ever more tightly to the new managerial and business credo of efficiency and rationalisation. This credo, as I discussed in chapter three, is becoming a dominant philosophy in the IT community and in one sense is a reflection of the commodification of more and more aspects of the practices of this industry. Having developed tools and techniques to better analyse and model user environments analysts are responsible for delivering systems which utilise the information gleaned from users, and particularly lower level users, so as to exploit them better. This is achieved through emphasising only one or two aspects of the systems design (e.g. control and cost savings) in contrast to a possibly more multifaceted systems build. This worries some analysts and systems managers, but the overwhelming majority of analysts and systems managers I interviewed and observed were largely ignorant of these issues and active proponents of the very business credo that is making their design activity more one dimensional.

Probably, the most cited case of a mass producer attempting to redress some of the more deleterious aspects of capitalist labour processes, via an 'opening up' of the design process, to a more democratic involvement of parties - management, designers and unions - is Volvo, in its Kalamar but particularly Uddevalla factories.

It is worth looking at the Uddevalla example because it shows some of the limits of what is possible and practicable within a capitalist economy. Uddevalla represents an attempt to 'socialise' production on a scale never seen before by a manufacturer. The specific aim was to reverse tendencies towards the deskilling and routinisation of labour. The plant was designed on a co-operative basis, with full trade union participation right from the start. Utilising a socio-technical design remit, key sections of Volvo management sought to give equal weight to social and technical considerations within the design. Volvo devoted huge resources to what Clarke (1990) calls the 'socialisation of production'. This involved the introduction of flexible technologies enabling complete build and a reskilling of the workforce, and facilitating the utilisation of small work teams who were largely responsible for the scheduling of their own work and collectively responsible for job allocation. Working conditions in the plant such as noise levels, cleanliness, safety and facilities, were also given high priority. Indeed, the company went to enormous lengths to create an attractive working environment where rest lounges with fully equipped kitchens and showers were provided and the wearing of track suits rather than overalls was permitted for workers and a redevelopment of all hand tools so that female workers could use them comfortably. One manager stressed why Volvo went to such lengths:

> Our workers wear designer clothes. They ski in Austria in winter. They go to the Greek islands in the summer. They have a professional lifestyle. They cannot understand and will not accept being treated differently at work (cited by Clarke 1990: 15).

It has been suggested by a number of writers (Clarke 1990, Berggren 1989, Hammerstrom & Lansbury 1991, Littler 1990) that the reasons why Volvo undertook such detailed work redesign is because of the specific nature of Scandinavian industrial relations and the particular nature of Volvos market. Historic labour shortages, powerful union federations, a corporatist and long-standing history of social democratic governments, coupled to a high value added, limited production, market sector meant that employers had to give consideration to workers' interests in the design process and that, in turn, unions and worker representatives were in a relatively strong position to secure those interests.

However, it is often forgotten, as Berggren (1989) points out, that many managers and industrial engineers within Volvo were opposed to the design and still are. Plant managers, in particular, feeling too much discretion has been given to the workforce at the expense of tried and tested systems of control. Other sections of management, as Hammerstrom and Lansbury (1991) have argued, are worried that Volvo's rising company sales which strongly inclined the company to experiment with work improvement will rapidly decline, particularly with Japanese entry into the luxury car market. This indeed is what happened during 1990 and 1991 when Volvo experienced significant losses and *had* to begin initiating rationalisation plans to ensure its survival (The Times 1990, 1991).

The irony is that this experiment, the most advanced of its kind has ended. Volvo closed down its Uddevalla plant in 1994 as a result of intensified competition from more main stream manufacturers.

Summary

I have argued that a software bottleneck exists in the IT industry and that the proposed solutions to it, ranging from more sophisticated modelling tools through to more participatory design approaches, do not resolve the fundamental causes of that bottleneck - an inability to accurately model the social in the technical.

Debates on securing greater user involvement in the design process through developing more participatory design tools and methodologies fail to recognise that, in a society in which design is geared towards the production of exchange-values rather than use-values and in which labour power itself is reduced to a commodity, the scope for democratically designed work systems is minimal. Further, I have argued that the actual origination, composition and aims of the project team - the most common approach to design - is anti-democratic.

Likewise, I have argued that tools and techniques of design perfected within the capitalist economy are embedded with the philosophy of exploitation of that society and cannot simply be lifted and applied to the construction of a socialist economy, or be rendered democratic merely by being used Participatively. Systems designers have developed tools to more accurately model the social, however, the majority of those tools, both in their architecture and use, model only one particular dimension of the social. In effect the interests of the various groups that constitute the social are not always encompassed in a particular design build. Despite attempts to ensure greater user participation in design the interests of dominant power elite's and their need to maintain and extend relations of surplus-value extraction remain, more or less, unchallenged; indeed, they are reinforced through many of the tools, methods and practices of analysts.

In the following chapter issues relating to user participation in design are discussed in the context of trade union policy and strategy. I examine the ways in which dominant power relations and bargaining cultures act to distort and limit employee involvement in design - thus inhibiting management in tapping into the experience, skills and creativity of workers - and consequently reproducing tendencies towards user dissatisfaction and system failure.

Trade Unions, New Technology and Work Redesign

Introduction

In the above chapter I argued that although there are increasing calls for greater user participation in the systems design process, this participation remains restricted. One manifestation of this restriction is the practice of the project team approach to design. Ostensibly, project teams, in as much as they may encompass user representatives, can appear relatively open and democratic. In practice, however, the project team serves to reinforce the domination of particular interests over others and is anti-democratic in both its workings and in its intent - which is to secure the 'system' interest.

With the development of complex real time systems management increasingly require employee participation in design; however, senior managers and systems departments, generally, do not want to relinquish their control over the systems design process or encourage forms of participation which may lead to critical evaluations or even rejection of the systems they propose. Importantly, few systems managers I interviewed felt unions should be involved in systems design at the detailed and practical working level of the project team. Rather, members of the project team may ask trade union representatives for their views on a particular topic and then report back to the project team but they did not want union representatives involved in the day to day decision taking activities of the project team; these areas were seen, by systems staff and user managers alike, as sacrosanct - as strictly managerial domains. In effect unions are largely excluded from involvement in project teams and the crucial design work they carry out.

On the basis of interviews of trade union officers and shop stewards this chapter examines the more general involvement of trade unions within the design process and, in particular, union attempts to utilise New Technology Agreements (NTAs) and establish joint consultative procedures with employers. The types of agreements unions make, their assessment of these agreements and the difficulties unions face in securing their members' interests within the design process are explored. It also examines the impact of new technology on skills, work organisation, control and trade union membership patterns. Finally, it examines the changing industrial relations climate that is emerging, partly as a consequence of the broader processes of restructuring discussed in Chapter One and, more specifically, as a result of particular government and trade union strategy and policy[1].

Trade Unions and New Technology

Trade unions have always been concerned with the results and implications of technical change on job demarcations, skills, pay and job security (Batstone 1987, Coats 1988, Hyman 1989, Jackson 1991). However, widespread concern over the implications of micro-electronics based technologies and in particular the use of information technology as a rationalising technology (Ryan 1991, Thompson 1991) has prompted many trade unions into producing a spate of documentation and policy statements in an attempt to clarify their position *vis-a-vis* this technology and process of change[2].

The majority of trade unions I interviewed recognised the need for investment in new technology but qualified this with the need to ensure that their members' interests will not be undermined as a result of technological changes taking place in the workplace. This is the official position of the TUC (1979) document Employment and Technology. However, the degree of individual union acceptance of technological change, along with awareness of the issues involved and strategies and programmes to tackle it, differ dramatically.

The EETPU, for example, argues that whilst many other unions' reaction to new technology:

> Is increasingly strained, tested and ... found wanting. The EETPU is different and proud of it. We are unequivocal. Technological progress is vital to industrial survival. Our concern is to ensure that it is successfully harnessed, not

> fearfully rejected by the industrial backwoodsmen in some short-sighted emotional spasm (Hammond 1987).

The EETPU sees itself in a `pioneering' role, riding the crest of a technological wave. To this end, the union runs its own training colleges, with the latest micro-electronic equipment explicitly seeking to achieve higher status for its members through a programme of education, retraining and monopolisation of key positions (EETPU: 1987). Whilst the EETPU is relatively optimistic about the benefits accruing from the introduction of new technology, NALGO, argue that:

> We are convinced that the changes brought about by new technology can only be accommodated by society with appropriate and radical Government measures at the national and international levels ... The extreme free market philosophy of the present British Government ... is wholly inadequate to the social challenge posed by new technology (1989: 4-5).

NALGO strongly believe that:

> There is no automatic route whereby new technologies will be translated into social advance, rather: Trade unions must have a positive role in persuading governments to adopt appropriate policies for dealing with technological change (1989: 54-55).

This view was echoed by an official of the MSF who argued that whilst:

> The union accepts new technology, as a fact of life, its introduction and use must be carefully negotiated to protect members' interest (Regional Officer MSF).

The real issue for many unions is not the technology itself but the social context of its introduction. ASTMS (1986), for example, are acutely aware of the impact of new technology on jobs, skills and working practices. Indeed, all the unions I interviewed sought some kind of consultation or negotiation with employers over the introduction of new technology. Some unions attempting to achieve this through specific technology agreements; others through existing collective bargaining procedures, but all emphasise that it is difficult to get employers to negotiate with them over these issues.

The TUC (1981) recommends that unions attempt to sign new technology agreements (NTAs) with employers. NTAs were originally pioneered by trade unions in Scandinavia in the early 1970s (Benson & Lloyd 1983, Gill 1985); their adoption in Britain reflected trade union concern in the late 1970s with extending democracy in the workplace (Benson & Lloyd 1983). The TUC (1981) issued a set of negotiating guidelines for member unions wishing to secure NTAs with employers[3]. In practice many of these guidelines relate to issues of staffing, health and safety, earnings and hours. Apart from a general emphasis on the need to ensure that new technology is introduced through a process of collective bargaining and consultation the TUC guidelines offer no practical advice as to how union representatives are to actively intervene in the process of design. TUC guidelines and member policy, generally, does not address the importance of union involvement in the project or design team at the critical stages of requirements setting and system boundary definition; these areas still tend to be perceived as 'managerial' and sacrosanct.

Most unions try to respond to technological change by developing a `model technology agreement' which consists of a set of guidelines relating to issues such as pay, demarcation, skilling, manning, health and safety, etc. Only two unions, the GMBTU and TGWU, said that they do not operate model technology agreements. This is not to say that they do not attempt to seek agreements with employers over the introduction of new technology, rather:

> Due to the specific structure of the T & G and the multiple business, industrial, public and private sectors, in which our members work, it would not be practicable to operate a model technology agreement (Education and Research Officer TGWU).

Unions that operate model agreements emphasise that, in reality, a number of variables intervene to ensure that the final agreement adopted with the employer comes now nearer, now further, from the model agreement:

> This is just a model agreement ... a guideline for our negotiators ... we pride ourselves in being able to custom our agreement to suit various employers, in other words, it is not rigid dogma (Union Officer MSF).

Many unions argue that employers often refuse to enter into negotiations over new technology. Thus BIFU note that:

> New technology, its implementation and development in banking and finance continues to progress in the United Kingdom at a very fast pace, without negotiation and little consultation with BIFU. As a result ... the BIFU National Executive Committee resolved to ... promote an awareness among all financial staffs of the needs for union membership to protect them from redundancy resulting from developments in micro technology and also to arouse public

> opinion on the social irresponsibility of such wealthy employers on this issue (1986: 2).

An USDAW official highlights the difficulties many unions face in trying to get technology agreements by detailing how, in the retail sector alone, employers use `the vulnerability of part-time and temporary workers to undermine union organisation and forestall any discussion concerning technological change, or work reorganisation' (Regional Officer USDAW).

All unions, whether they had model technology agreements or not, sought to get negotiation with employers. However, different unions have different problems and degrees of success in achieving these aims. BIFU, for example:

> Have had a concerted policy of trying to get employers to enter into new technology agreements, but banking employers just don't seem to want to have it (Union Officer BIFU).

ASTMS and TASS argue that they have been relatively successful in securing technology agreements with employers because their members are in a strategic position vis a vis new technology and management strategy, and are better able to see what is going on; they also win the confidence of employers due to their white collar status, a view shared by APEX, which has the highest number of new technology agreements.

However, even where unions do achieve a relatively high number of agreements, one should be careful of over exaggerating the capacity of the union to influence the shaping of new technology because: 'In most cases, there is no negotiation by employers' (Union Official MSF).

It is also worth noting that APEX, ASTMS and NALGO have signed mainly procedural agreements regarding the future introduction of computer based office and administrative systems, whereas TASS has signed more specific and combination agreements regarding the introduction of specific changes, usually the introduction of computer aided drawing technology into the drawing office (Williams & Steward: 1985).

Only a few of these agreements allow for worker involvement at the design stage of a new system and even less at the earlier required planning stage (Daniel & Millward 1993, Mcloughlin & Clark 1994). Unions' ability to achieve their aims differ widely, depending upon a number of variables from co-operation of the employer, the type of technology being introduced, the occupation of union members, their awareness and strategic position *vis a vis* controlling the changes, the competitive state of business and the nature of union solidarity.

Most of the union officers I interviewed believe that the TUC policy in relation to new technology is the best that can be expected:

> Given that the TUC only has the power its members give it (Union Officer, USDAW) and given: current political/economic climate (Union Officer MSF).

An ASTMS official argues:

> Whilst the TUC may have a role for smaller unions in assisting them in coming to grips with the issues surrounding new technology, it can be of little help to the larger unions, nor would its interference be welcomed (Regional Officer ASTMS).

However, some officials argue that TUC policy on new technology and the guidelines and assistance it gives to various unions on this matter, is not enough, one official of the EETPU arguing that:

> the TUC has done bugger all concerning making individual unions aware of new technology issues (a) because the TUC have not got the experience, (b) it has not got the funding, and (c) it has not got the willpower. As a consequence, individual unions are forced to go it alone, using their own limited resources to finance their own research and training programmes (Regional Officer EETPU).

NALGO argues that the TUC directives on new technology are 'abysmal' and:

> Its lack of action during the period 1979-1987 when all these changes have been going on, is worthy of contempt (Union Officer NALGO).

Two hundred and forty NTAs were concluded between 1977 and 1983 (Williams & Steward 1985). However, by the mid 1980s the new technology agreement initiative lost impetus for a variety of reasons (Batstone & Gourlay 1986, Jary 1987, Millward *etal* 1992, Daniel & Millward 1994). First, TUC plans to negotiate NTAs were formulated at a time of relatively full employment and when union bargaining power was strong. However, throughout the 1980s and 1990s this power has been eroded through successive government legislation and rising unemployment. Consequently, many unions have found it difficult to achieve even the modest aims set out in the 1979 TUC directive. Indeed, a CBI survey of 225 NTAs concluded that even in the larger workplaces, under 20% of employers negotiated over technical innovation. Overall, 44% `communicated', 42% `consulted' and a mere 9% negotiated (McIlroy 1991). Second, management has always been reluctant to concede power over issues relating to the design and organisation of work. - favourable employer legislation buttressed by high unemployment rates and legislative changes have merely strengthened such views amongst management (Hyman 1989, Behagg 1990, Marsh 1993). Third, the lack of an alternative `vision' on the part of many trade unionists to the dominant managerialist and free market philosophy sweeping through managerial and political circles has served to curtail possible `alternative' design proposals. Fourth, the TUC's long standing commitment to technological change as inevitable led to a focus on employment rather than job content and work organisation (McLoughlin & Clark 1994). Fifth, TUC policy underestimated the resources required in terms of education and research to effectively service union negotiators. Finally, divisions within the trade union movement mitigated against establishing a united front policy *vis-a-vis* the trade unions and employers (Clarke *et al* 1984, Moore & Levie 1985).

Union Involvement in Pre-Technology Negotiations

Trade unions tend to see technology and systems design generally in a deterministic fashion. The technology is often taken as given and likewise the logicality of its design is seldom questioned. Areas relating to the actual processes of design and the possible ways in which the interests and values of designers, managers and suppliers may shape the products and systems designed is generally ignored by most unions. - these areas are invariably seen as `managerial'. Union response to new technology is further conditioned by prevailing collective bargaining culture which both legitimises and limits the unions role to one of negotiating over terms and conditions *within* the prevailing status quo. Consequently the technology often appears `black box', closed and neutral and remains unquestioned.

Because the majority of union officials I interviewed perceive technology in this way their strategies for dealing with technological change tend to be limited. McLoughlin and Clark stress the need to `open' up the black box and understand technologies as `engineering systems':

> That is, rather than just being pieces of hardware and software, technologies are also conceptualised as systems based on certain engineering principles and composed of elements which are functionally arranged (configured) in certain specific ways. In this way technologies, or more accurately engineering systems, can be defined in terms of three primary elements: `system principles', an overall system configuration, and a system implementation or physical realisation in a given technology. The first two elements we call architecture, and the third technology (1994:132).

Most union officers I interviewed fail to recognise that at critical junctures during the process of change, for example, through particular design decisions over architectures or choices of technology concerning their implementation, the key technical features of a given engineering system become `frozen' into a specific form - a process referred to by Pinch and Bjiker (1987) as `closure'. This closure refers to the `stabilisation' of an artefact as consensus emerges amongst key social groups involved in the design process. These technical influences shape the `design space' available to organisational actors (McLoughlin & Clark 1994); however, most unions tend not to participate in this `design space' and consequently too readily accept as given that which is contestable and negotiable.

Lack of union recognition of technology as an `engineering system' and consequently something that is not immutable or incontestable is further hampered by the fact that management do not want unions involved in design. Rather, in the best of cases, management would inform the union of the company's decision to bring in new technology and then seek to secure the unions co-operation over the `working details', once implemented, via some form of technology agreement, or, through existing bargaining procedure. In the worst cases, the company would simply by-pass the union altogether. This was substantiated by a number of analysts and consultants I interviewed:

> It really doesn't make much sense to bring unions into pre-technology negotiations ... and the actual detailed process of design.....it is up to

management to define the parameters and objectives of the system ... obviously it is advantageous, however, to involve the unions in part of the exercise ... to secure good will ... but also to fine tune the system ... usually once the system is up and running (Systems Analyst, US Electronics Company, Scotland).

If you catered to every passing whim of the trade unions ... you would never see a design implemented ... its simply not their area its management prerogative to decide the system ... you can discuss with the unions issues of ergonomics and possible job allocation and demarcations, but you don't pander to them and compromise the system (Senior IT Consultant, Major Software/Hardware Manufacturer).

The difficulties unions face in securing involvement at the critical design stage was brought home in a major survey of over 2000 workplaces where it was found that:

So great has been the support of workers and trade union representatives for technical change that management have not had to use consultation, participation, or negotiations to win their consent to change. Even major changes have been introduced with suprisingly little consultation (Daniel 1987:32).

I found minimal union involvement in the actual choice of technology, its applicability, make, cost, design features, or criteria regarding its integration or replacement of existing work processes. However, unions could refuse to co-operate with management over the operation of technology, so management might actively seek union co-operation in order to obtain maximum utilisation of the initial investment:

Because of the breadth of changes taking place here, I felt it essential we involve all the unions in the process and I managed to convince senior management of this ... you can't just introduce CIM and JIT out of the blue ... it's better to get the unions involved ... besides we have excellent relations here and there are some very experienced and qualified representatives in manufacture and design whose expertise and knowledge has greatly enhanced the development of the system ... why exclude them for the sake of some dogma (Systems Manager, Automotive Components Manufacturer, Wales).

Equally, unions might go so far as to hire private consultants to propose an alternative system of working to that being put forward by management (TGWU 1983). In many cases, particularly where advanced work systems were being introduced i.e. flexible work station technology, computer-aided design and manufacturing systems, or computer integrated manufacturing systems, neither the actual management, or union, of the firm introducing the changes may have sufficient expertise to understand the complexity of the technology, or system (TGWU 1983). Particularly with large scale changes, involving sophisticated technological systems, it is often the case that an employer will set out a series of objectives (e.g. increased productivity, better quality, etc.) and present these to a variety of `specialists' - engineers, systems analysts, consultants, and firms specialising in the design and manufacture of specific technological hardware, who in turn, will present their proposals to the firm in the form of a series of achievable goals for a certain initial investment (Brown 1985). Thus, Westinghouse Furniture Systems installed flexible work environments into its factory, after consulting Ergo-Tech, who convinced Westinghouse that for approximately £600 investment per employee, Ergo-Tech flexible work stations would save Westinghouse space, allow for better tool placement, provide flexibility, reduce employee interface, noise levels, work in progress, parts shortages and provide an orderly environment, better position in the labour market and enable the company to attract and hold onto employees (Brown 1985: 50).

Of course, not all firms introduce technology on the scale of a fully integrated manufacturing system. One survey of engineering firms in South Wales indicates many companies lack the capital to invest on such a scale, rather seeking to introduce a particular technology to produce a certain component, with high demand (Thomas 1986). An MSF official commented on the general process of new technology introduction:

> the most enlightened employers recognise new technology costs a lot of money.....they thus want staff who are trained; this is particularly important because some employers actually consult with us before introducing new technology. However, the majority simply introduce it through the back door in piecemeal fashion (Regional Officer MSF).

APEX reports that

> neither at national, or local level, are we involved in pre-technology negotiations, management and employers keep the union in the dark concerning the design and implementation of new technology. Any negotiations that do take place, arise only over issues resulting from that technology's introduction, i.e. health and safety, demarcation, etc. (Union Officer APEX).

A regional officer of BIFU stresses that the union has tried to get technology negotiating rights for years:

> and in one or two places, there have been genuine attempts to consult and identify problems for the negotiating committee to deal with, but even these do not add up to much (Regional Officer BIFU).

ASTMS argues that although the union:

> wasn't in on pre-technology design negotiations, we do add to its specific working out ... i.e. who works on what, for how long, where machinery should be situated, how long it should be operated, rates of pay, etc. (Union Official ASTMS).

A shop steward at an electronics company in South Wales, who is also an engineer for the company, said that in choosing a new machine he did not consult the operators who would be using it, let alone his fellow APEX shop stewards. Unsurprisingly, he chose the machinery in terms of criteria of: `efficiency, cost effectiveness, and reliability'. A similar approach was displayed by two analysts I interviewed:

> I choose the hardware and software I think is going to be most efficient ... I can't afford to complicate matters by leaving these decisions to users, or getting union representatives involved, too deeply, in the design process (Systems Analyst, Major Electronics Defence Contractor, Scotland).
>
> Once the boundaries of the system are settled and only then ... you need to discuss the workings of it with the various unions whose members will be affected ... here one would discuss possible demarcation issues, re-grading, ergonomics and health and safety ... the union input here can be quite useful ... but even here I know a lot of analysts just perceive union involvement as more work and pain ... they shouldn't but they do (Senior Systems Analyst, Large Medical Equipment Manufacturer, Scotland).

Trade union capacity to influence crucial pre-technology negotiations is extremely marginal. However, once a particular system has been decided upon by management, then the process of negotiation surrounding its use usually begins with different unions being now more, now less able to exert influence over the changes taking place. Thus, whilst the GMBTU argue that 'the union has no influence, whatsoever, on the design or introduction of new technology' (Union Officer GMBTU); others, like ASTMS have been able to:

> secure new technology agreements which stipulate that the company cannot introduce new technology for a period of six months and even then, only after consulting the union (Regional Officer ASTMS).

However, all the unions I interviewed argued that it is the refusal of most employers to involve them in such `sensitive areas' that is the biggest obstacle to limiting the scope of union influence on technological change and work reorganisation.

Union Involvement In Job Re-design

Lack of union awareness of technology as an `engineering system' and their ability to intervene at the crucial level of the design team prior to the `stabilisation' of the design has already been noted. Union awareness of the job issues that may flow from a particular design configuration once it is `stabilised' is, however, more developed.

Many union officers I interviewed were particularly concerned, for example, about the ways in which management are utilising new technology to support the introduction of so called `Japanese style' management practices. New bar coding, laser scanning and surveillance technology often supports these practices as the following union officer candidly reports:

> You don't clock on in this factory....there are very few foremen and supervisors......quality inspection is also reduced. Quality personnel are no longer over your back.....it can give the impression of freedom, management may peddle it as co-operation or high trust work relations.....underneath the surface however you have employee numbers activating machines, technology surveying when a machine is turned on and off....at what speed it is run...more technology scanning quality....and all this in a culture which emphasises individual employee responsibility....its control in a new guise (Shop Steward, Multinational Car Manufacturer, England).

Most unions are apprehensive about the introduction of new job re-design schemes at a time of intense market competition, recession and a political climate openly hostile to trade unionism, arguing that they are an attempt to subvert traditional working practices and union negotiating structures. Some, however, argue that these practices can be made to benefit employees, so long as the union can get good negotiating rights.

More than one systems analyst made the link between the nature and speed of systems development and the current political context:

> When you really think about it ... much of the growth in IT has taken place over the last eleven years under a Thatcherite Britain where political and social conditions were right ... but they are not always going to be right ... God, when I think about how much is stored on the mainframes and how reliant we are on IT its unnerving, we're lucky not to have serious union problems and militancy (Senior Systems Analyst, Major Private Energy Utility, Wales).
>
> I've got to be honest with you and say some of the unions here have good cause for concern regarding a lot of the technology introduced recently ... the figures speak for themselves, not only in job losses, but increase in work loads ... we are all in a similar boat ... management want to see a return on their investments and they expect this return to show cost savings and productivity improvements ... certainly we wouldn't have got half as far ... had the political climate been different (Systems Analyst, Major Public Utility, Midlothian, Scotland).

One union that is very conversant with the issues surrounding job re-design is APEX, which delineates five major methods of job re-design: (1) Scientific management, (2) Job rotation, (3) Job enlargement, (4) Job enrichment, and (5) Semi-autonomous work groups. Concerning scientific management, APEX argues:

> This theory does not really deserve the title of a job re-design method. It is a technique to be avoided at all costs ... skill, decision making, responsibility, variety and ultimately, all thought are removed from work (1985: 14).

Importantly, the union argues that:

> A wide range of efforts are now under way in Western Europe ... to introduce this method in banks, insurance companies, the retail trade and even hospitals, whereas, originally, it was a system applied to manufacturing (1985: 14).

Job rotation, APEX argues, involves:

> The planned rotation of a worker through a number of jobs of roughly equal skill and challenge (1985: 15).

This system too, is regarded by APEX as unsatisfactory:

> Because it neither attempts to improve the quality of individual jobs, nor to reward additional skills ... tacitly admitting that each job in a group need not be changed. We refute this. The basis of our whole approach is to redesign individual jobs from component tasks. It is questionable whether the method will be relevant in the future. New technology can be used to take apart a job, redefine its elements and merge these with other tasks or whole parts of other jobs. This is particularly true of office work (1985: 15).

Concerning the issue of job enlargement, APEX cites the European Trade Union Institute (ETUI) definition as: `that process through which several simple elements are combined into one more complex job' (ETUI 1981). APEX notes:

> The major limitation of job enlargement, like job rotation, is that the enlarged jobs may merely consist of boring tasks combined in a new way (1985: 15).

Career development is also:

> Difficult to achieve, since jobs are still restricted by horizontal levels of work experience (APEX 1985: 15).

On the issue of job enrichment, APEX again cites the ETUI definition:

> By job enrichment, one normally means a scheme, whereby the employee is given more responsibility for planning, organisation of work and daily checking of production (1985: 16).

Job enrichment is a component part of many Japanese style management practices, such as the use of Quality Circles and organisation of production along the Kanban system, so that although job content may be extended, it also tends to lead to a vertical transfer of tasks. However, APEX regard this system of job design as conforming better to their definition of job design than the other methods, in that it gives:

> Employees greater involvement in decisions that have traditionally been the responsibility of management or specialist functions (1985: 16).

Other unions, however, particularly those whose members are affected by new work practices and associated technological changes, are more critical:

> Quality circles are being used by senior management to replace many supervisory staffs and to undermine some of our members jobs by getting workers to self-police their own activity ... this method of work organisation can also weaken the authority of shop stewards as management appeal directly to workers in the team (Union Official ASTMS).

This point was also made by one of the systems managers I interviewed:

> The workforce here carry a little plastic card rather like a credit card. It is used not only to clock on but to switch on the machines and log both the productivity and quality of their work ... by logging number of defects and stoppages ... we also have a variety of shop floor data capture technology including cameras, transducers in bearings to monitor performance and running times of the lines ... this is connected up to a computer system which gives senior management a direct picture of production at any time of day or night ... it has also enabled us to dispense with some supervisory grades (Systems Manager, US Electronics Company, Scotland).

The final method of Job design, APEX considers, is semi-autonomous work groups which the ETIU regard as:

> A broadening of the job enrichment idea to the whole work group (1985: 16).

The work group is given responsibility for planning, ordering of supplies, organisation of work and checking of production. APEX note that:

> Total autonomy of the group is very unusual. Middle management and supervisors still have responsibility for overall co-ordination. However, there are cases were supervisors are made obsolete. Their duties are transferred to the work group. Either the workers collectively share these responsibilities, or someone inside the group is appointed as team leader (1985: 16).

Whilst regarding this method, on the whole, in a favourable light, APEX notes that it can cause problems between work groups, resulting in competition and friction, further:

> Over zealous group loyalty may cause problems for staff representatives trying to represent a multi-departmental concern (1985: 16-17).

Other unions, however, seem to have a better grasp of the social context in which semi-autonomous work groups are being introduced and the aims of management in introducing them. An official of the MSF argued that many companies seek to introduce these systems as part of a package, involving single union agreements, no strike clauses, and multi- flexibilisation of the workforce. He cites the case of Nissan, in Sunderland:

> The effect of such practices, coupled to the social and political context of their introduction, has meant both an increase in the exploitation of workers: lengthening work hours, increased pace of line, reduced breaks, compulsory overtime, etc., and also a disillusionment with the union on the part of the workforce with less than 20% feeling the need to join the AEU because of its patently collaborationist role with the employer (Regional Officer MSF).

A TGWU official argued that trade unionists should be wary of management's objectives in introducing quality circles, multi-flexibility, Kanban, etc. He cites the example of Ford, whom he argues are:

> Trying to introduce new technology and cultural changes into the workplace, in an attempt to subvert traditional union structures, by going behind the backs of shop stewards and appealing directly to the workforce ... but they can't introduce Japanese style work relations into Britain ... you end up with a mutant child, a deformed system (Union Officer TGWU).

Concerning the use of Kanban, this official argues:

> Ford like many car manufacturers are using this system, or attempting to extend its use ... one of the consequences of this system being that the market now becomes a direct disciplining force, acting upon each individual worker, who is directly made responsible for quality, etc. (Regional Officer TGWU).

Kanban requires the internal flexibility and mobility of labour to enable management to re-deploy labour to whatever tasks are in hand. The system has its problems, in particular, it requires a set of supportive stable industrial relations and secure and reliable supplies (Oliver & Wilkinson 1987). If one part of the system should have any problems, for example, breakdown or industrial action, the whole system can grind to a halt. One TGWU official is adamant that the system cannot work in Britain:

> Britain is not Japan ... the whole history of British industrial relations, union structure, shop floor politics and social, political, cultural and ideological climate is different to Japan ... I cannot see Japanese style management taking root (Regional Officer TGWU).

Yet, a number of manufacturers are attempting to introduce the system (e.g. Fords After Japan project, Pirelli, Nissan, Lucas Girling). The TGWU official admitted that it had many benefits for employers, not just in reducing the amount of capital tied up in stock but in enabling them to meet new market conditions characterised by over-production which require firms to specialise and be flexible, produce limited batch runs and keep costs down.

However, according to one union official, it would be naive to assume that Japanese companies operating in Britain were adopting closer working practices with trade unions or designing more humane work systems because of this:

> In my experience Japanese management offers no more collaboration in the process of work design than any other management. Indeed, Japanese firms operating here are not high tech but low tech ... whilst these may not be representative of Japanese companies back home, in my experience, they operate neither with more sophisticated technology, or management practices, than either Swedish, German, American or even British companies ... there is nothing unique about what the Japanese are doing ... Given the economic climate, all companies are having to review managerial practices (Regional Officer ASTMS).

In contrast an official of the EETPU said that:

> Very few complaints come from our members working for Japanese companies ... many of these Japanese policies are progressive (Regional Officer EETPU).

However, the Chairman of the Welsh TUC was less enthusiastic:

> Japanese style management is a hollow shell ... workers don't have any real say in the management of plant, or operating decisions ... rather they vote on what colour overalls to wear, or what should be on the menu the coming week ... QC circles are a thinly disguised sop, masking employers' attempts to increase the

> exploitation of workers by getting them to align with the Company (Chairman WTUC and Regional Officer GMBTU).

No company he knew of would be prepared to tolerate workers' control of the productive forces:

> Even the Bullock Report which sought to bring unions and management together, on these issues, was little more than a piecemeal tinkering of the system ... and we have never been further from the substance of this report, or from tripartism (ibid.).

The TGWU and MSF have been in bitter dispute with the AEU over the latters acceptance of Ford's offer at Dundee and its attempt to sign another single union, no strike deal, involving Japanese style practices with A. C. Delco in Dunstable. The Japanese practices mentioned, are only a small part of the various strategies open to management to re-design work relations An APEX Regional Officer argues, `some employers are even attempting revitalised forms of Taylorism'. One should also remember that it is not a one way process: management has to take into account a number of variables when contemplating introducing a new work system, e.g. will productivity be increased, will quality be improved, is the market buoyant enough to justify the investment and risk associated with changes, is it worth antagonising unions, can union co-operation be sought, etc.?

Impact Of New Technology On Skills, Work Organisation And Control

In general terms new technology has had a disruptive effect on established occupational boundaries and skill demarcations and in some instances has challenged traditional boundaries between male and female jobs (McLoughlin & Clark 1994). Batstone and Gourlay (1986) argue that significant changes have taken place amongst maintenance, production and some categories of clerical workers. Similarly the WIRS (1990) Workplace Survey found that manufacturing establishments using advanced technology were more likely to have flexible working practices in both production and maintenance areas.

There was divergent opinion among trade union officials concerning the nature and pace of de-skilling. Some argue that in a market economy, new technology is bound to be used by employers to increase labour productivity and reduce the value of labour-power by simplifying its functions. Others argue that technology is not the most important factor in reducing members skills and control over the workplace but changing managerial practices, such as the introduction of multi-flexibility, JIT, part-time working or job sharing. Others argue that whilst technology, on the whole, accelerates both de-skilling and directly replaces living labour, its effects are not linear, rather, certain jobs may be de-skilled, others re-skilled, as a consequence of technological changes. However, virtually all agreed that once the initial time element of its introduction was overcome, they could foresee less and less labour being involved in the production process. Some argue that the labour remaining will be of higher skill, others that it will be de-skilled, yet others foresee the development of a central core of full time, relatively highly skilled workers and a mass of unskilled auxiliary and temporary workers, with little or no rights, moving in and out of firms to meet changes in market demand. All unions see the definition of skill as something to be determined by collective bargaining and negotiation; many argue that the effects of de-skilling can be offset by good negotiators. To give some idea of the complexity of the situation, we can look at the following cases.

SOGAT (now subsumed into the GMPU) argue that new technology has replaced the traditional skills of the saddle stitcher and bookbinder:

> We become, if you like, machine operators, not crafts people; and, in fact, we are an industrial union now ... printing is now a mechanised process, not a craft (Regional Officer SOGAT).

The apprenticeship used to be seven years, now it is two years, but on the other hand, there has been an extension of skills for some of SOGAT's members, for example:

> Tele-ad girls in newspapers used to just have to sell, now they operate VDU's too. Warehousemen used to drive truck or hand pallets but now they are driving more sophisticated trucks which has increased their bargaining strength and wages (Regional Officer SOGAT).

An ASTMS official argues:

> It is not possible to make general statements on technology and de-skilling ... for example, a plastic engineers company in Treforest introduced more sophisticated quality control equipment which led to a reduction in the number of workers but higher skills were needed to service these machines (Union Officer ASTMS).

However, this contrasts with ASTMS own publication highlighting in detail the de-skilling effect of new technology, in industry, manufacturing and services (ASTMS 1986). One union official argued that basically his:

> Members welcomed new technology on the grounds that it either (a) enhanced their skill, or (b) reduced boring repetitive work (Regional Officer NALGO).

This official also argued that his members' conception of skill was `purely subjective':

> In reality, new technology had reduced the amount of time employers spent on training certain employees, as well as facilitating the use by employers, of lower grades, to do formerly higher grade work (Regional Officer NALGO).

A NALGO shop steward confirms the use by employers of lower grades on formerly higher grade work arguing that in her experience the introduction of word processors into the office has led to an increase in the workload as the `girls were now expected to carry out a whole host of auxiliary functions, using the word processors'(Shop steward, Borough Council, Wales). This steward emphasised the need for union negotiators to be able:

> To negotiate wage rates, skill levels and grade commensurate to the changes taking place ... the union's ability to do this will become the decisive factor in determining members' skill (ibid).

An official of the EETPU argues that his members are:

> In a unique historical position ... whilst the use of new technology has led to the de-skilling of the general workforce, EETPU members' skills are either being maintained or increased (Regional Officer EETPU).

By extensive re-training programmes, the EETPU aim to increase members' skills and bargaining position (EETPU 1987).

BIFU reports that technological changes, besides leading to job losses, e.g., the loss of 5,000 technical and service staff, due to computerisation of cheque transactions between banks, also facilitate management in downgrading staff and simplifying functions:

> For example, a cashier was a front person for the bank, being expected to be able to deal with a variety of transactions and enquiries, now they have been reduced to stamping machines ... and even this job will soon disappear as a result of technical change (Union Officer BIFU).

A GMBTU officer, argues:

> There is nothing intrinsic to technological change which unions should oppose, indeed, in many cases, it actually benefits our members, most of whom see new technology as a necessary corollary of efficiency and productivity ... any impact it has upon job demarcation, skill levels, etc., can be minimised by good negotiators (Regional Officer GMBTU).

McLoughlin and Clark (1994) argue that WIRS evidence confirms the picture that new technology is not leading to significant job losses or de-skilling[4]. However, most union officers I interviewed argued that the cumulative impact of new technology will be to create significant job losses. Whilst individual unions could cite examples of skill enhancement the obverse of this was usually significant job losses as a precondition, or consequence, of the introduction of most new technology. A further factor to bear in mind is that most new technology is precisely that, i.e. *new* - its knock-on effect on skill levels, as a consequence, has not been evenly felt and its 'de-skilling' potential has been mediated by workers currently operating through the changes. For example, an official of TASS reports that a company manufacturing circuit breakers had introduced computer aided drawing equipment into the office, whilst trying to maintain current rates of pay. The company and union entered into dispute and ACAS was brought in to arbitrate. ACAS found in the union's favour, arguing that employees should receive a 5% pay increase for operating CAD, as it represented an increase in the level of their skills. Yet in the union's own literature, it is argued that CAD reduces the overall skill level of the drawing office (TASS 1985). So why the anomaly? The official responded:

> The decisive argument was whether, or not, there was a new skill attached to the use of CAD and VDU's in the drawing office ... the key word being *new* for given a set workforce operating an existing practice, it is obvious effort must be exerted on its part to learn a new skill, if confronted with a new technology ... ultimately, however, by the second or third generation that technology has removed not only the need to learn traditional draughtsmen and secretarial skills

> but probably removed the need for that worker altogether (Regional Officer TASS).

Buchanan and Boddy argue that

> Computing technologies make demands on human information processing and decision making skills, reduce the need for some manual effort and skill, and introduce new forms of work discipline and pacing (1983: 246).

However, the absence of a clear managerial strategy *vis a vis* new technology can enable workers to exercise considerable influence over job content resulting in an informal clawing back of skills by those groups of workers who are able to re-negotiate the content of their jobs and present the case for re-skilling on the basis of them taking on additional tasks and knowledge.

Trade Union Reaction to Government Policy on Manufacturing

All the trade union officers interviewed, with the exception of the EETPU and AEU, thought that the Government's monetarist free market philosophy was both misguided and damaging to the long term economic prosperity of British industry. Most unions argued for the re-election of a Labour Government, committed to some form of reflation of the economy, re- nationalisation of recently privatised industries, extension of social services, health and education and implementation of a more collectivist structure for negotiating economic development and industrial relations. A minority of union officers argue that they do not believe it is possible to reconcile the interests of labour and capital in a market economy stressing the need for a `caring social system based upon a planned economy'(NALGO 1989:11). The introduction of new technology and changing working practices by various employers has coincided with recession, rationalisation and mounting unemployment which has had the effect of masking specific policy choices of Government, or rather giving them a sense of inevitability, making it difficult for some unions to perceive whether the changes taking place are a result of specific policy, or ongoing technological processes. Most unions, however, argue that the Government has fostered a political and social climate enabling employers to go on to the offensive and introduce new working practices.

An official of the EETPU argues that such rapid introduction of new technology and changing working practices would not have come about, were it not for this Government's stand and the consequences of recession:

> Which have made everyone aware that efficiency must be increased (Regional Officer EETPU).

As far as this official is concerned:

> Britain needed a shake out anyway (Regional Officer EETPU).

An official of the NGA (now subsumed into the GPMU) argues that it is not the introduction of technology per se which has threatened its members:

> But the political and economic environment created by this Government which has allowed certain newspaper owners, like the Thompson group, ... to smash the NGA's power over compositing (Regional Secretary NGA).

An official of ASTMS argues:

> It is quite clear that new technology and changing working practices have been introduced with less cost for British Industry than in the past, under Labour Governments, because of the hard line monetarist philosophy of this Government which has put employees on the defensive (Regional Officer ASTMS).

A TGWU official argues that this government:

> Is a Government of landlords and stockbrokers ... but then British Government, generally, has never been attuned to the needs of industry ... Wilson was going in the right direction ... Thatcher talked of increasing efficiency and service but did nothing to ensure the viability of British firms, she simply let market forces take their toll ... we can't hope to be competitive without state directive and co-ordinated planning, along the state capitalist lines of Japan or Sweden (Union Officer TGWU).

According to an official of the MSF:

> This Government has done bugger all to help British industry ... look at the cut-backs in R & D and in manufacturing investment ... this will have devastating long term effects ... This Government is butchering British manufacturing and handing it on a plate to foreign competition ... her rhetoric of fitness and efficiency is simply ideological ballast to attack labour ... the reality is she has done nothing concrete to help British manufacturing, whose output is lower today than in 1979 ... the Government is also dismantling the labour markets through neglect (Regional Officer MSF).

I put it to this official that maybe it was not a question of neglect but Government belief in `free market philosophy' - that the weak go under, the fitter survive, with unemployment acting to discipline labour, and recession facilitating employers in the restructuring of labour markets:

> Yes, this is what she wants but it won't work because other countries like France are bailing out their industries and providing the R & D and finance to put it on its feet ... it's all right saying the weak can go to the wall ... but when you are in a system constituted by chronic over-production all companies are volatile and need all the help they can get (Union Officer MSF).

Union critique of government policy flows from a belief in some form of Keynesian pro-active state policy *vis a vis* planning of the market economy and social provision of jobs and services. The majority of union officers believe that monetarist `hands off' state policy has considerably weakened British manufacturing, particularly in the light of substantive state support in countries like Japan and Germany. Moreover, unions felt that by pursuing a policy of non-communication with unions the government has undermined many of the possibilities of new technology through creating a climate of fear and recrimination rather than co-operation.

Single Union and No-Strike Agreements

There is virulent polemic between the various unions over the issue of single union and no strike deals (Hyman 1989, Marsh 1993, McLoughlin & Clark 1994). It is not so much the issue of single union agreements, in themselves - which most unions seek, and, argue are nothing new in Britain - but the specific content of these agreements which have been changing, along with the changing economic and political climate. The most heated area of controversy is the signing of no-strike deals and the poaching of other union members.

The EETPU, in particular, comes in for condemnation from virtually every quarter. Mark Gregory (1986) uncovered the material basis of this condemnation in the EETPU's signing of no less than 18, out of 21, single union no strike deals in 1986 alone. The EETPU is currently the leading exponent of the 'no-strike' single union accord. For the EETPU the strike free path to union representation has become more of a philosophy than a negotiating ploy. As Eric Hammond, the Union's General Secretary puts it:

> Of course there are people, sects and nuts who actually believe that in being involved in strikes, workers find out how to struggle and this leads them on for the revolution. My view is that the trade union function is to deal with matters in a way which doesn't involve workers in industrial action (cited by Gregory 1986:32).

This non-adversarial approach to industrial relations has become the basis of an extensive and highly publicised marketing campaign to coax more employers into signing up with the EETPU. Hammond admits that often as not, it is also directed against other unions:

> I see myself in competition with my colleagues in the British Trade Union Movement (cited by Gregory 1986: 32).

An official of USDAW argues that most unions, his own included, sought single union agreements and had done so for years. However, the substance of these agreements has changed:

> The decline of traditional industrial sectors like steel, shipbuilding, motor manufacturing, engineering, etc., themselves the repository of multi-craft based and industrial unionism, has given way to the formation of newer industries often based on green field sites and it is these that are the repository of the new 'no-strike' multi-flexibility deals (Regional Officer USDAW).

For USDAW one of the biggest problems is:

> Persuading anybody in a shop, certainly in many shops, that they have got anything to do with the working class ... thus a saying which certainly applies to the larger and better shops, that 'snobbery kept them in poverty' ...Particularly in the big stores, these people see themselves as professionals like doctors, or lawyers, or something ... of course, in food retailing it is not so, but this highlights our problems as a union (Regional Officer USDAW).

Because of the nature of the retail trade, the high numbers of part-timers involved, the ideology of professionalism, particularly in big stores like Marks and Spencer, Debenhams or House of Fraser, it is difficult for USDAW to organise and get single union agreements. Where the union does have agreements, the official argues, it does so:

> Not on the basis of tendering for them or stabbing another union in the back ... we usually get them at companies where no other union has any interest ... I'm not for unions coming into an area they think holds the possibility of potential

members, without them having the facilities and the organisational expertise behind them (Regional Officer USDAW).

The GMBTU stress they have to take account of the fact that many employers, particularly on green field sites, are now tendering out contracts to various unions:

> We have to get in there and offer the best deal we can, if we don't other unions will ... there are three types of employer: (1) Those who know what union they want from past experience; (2) those who tender out for the best deal they think they can get; (3) those employers who don't want any union at all (Union Officer GMBTU).

This official argues that:

> Competition between trade unions for a declining number of 'contracts' with employers is fierce, as each union attempts to produce the most favourable package for the employer (Union Officer GMBTU).

This situation produces:

> Deplorable tactics such as those of the EETPU at Wapping but even agreements like the AEU's at Nissan are anti-trade union agreements (Union Officer GMBTU).

This is a remarkable series of statements given the GMBTU's own signing of single union no-strike agreements.

Like most union officials interviewed, MSF reiterate that single union agreements are fine, in principle, but that the changing economic and political climate has had a profound impact upon the substance of the agreements and not just on green field sites. For example, at an electronics in Abercynon, the employer tore up the old multi-union agreement involving APEX, TASS and the AEU, and argued that it now sought single union representation at the plant:

> [the company] now expects us to parade on stage like in a fucking beauty contest with other unions from whom it will pick and choose whoever is best suited to its needs ... well its not fucking on ... already APEX and ourselves have refused to go on parade. We are not prepared to satisfy [the companies] demands ... it's *no* to multi-flexing, part timing and job losses ... but what have the AEU done ... true to fucking form they have agreed to accept the company's terms (Regional Officer MSF).

This highlights the dilemmas arising out of a strategy of single union agreement. Yet the same official still maintains that the single union agreement strategy is fine so long as cordiality between unions can be maintained! Yet the reality would seem to suggest this is less and less practicable - the same official said:

> Unions like the AEU and EETPU are fucking disgusting. They are traitors to the working class ... they brag they have sole negotiating rights but they haven't because most of the bloody workforce simply don't want to belong to a union that is collaborating with the employer ... For example, at Nissan less than 20% of the workforce are in the AEU, even though it has sole negotiating rights....We are going to oppose the 'new realism' of unions like the AEU and EETPU more and more and so is the TUC ... the EETPU should have been kicked out of the TUC for what the Bastards did at Wapping ... the TUC should have acted firmly (Regional Officer MSF).

Whilst this particular union official believes the fight against `new realism' has begun, other union officials are less sanguine, arguing that the TUC only has the power its constituent unions give it, or that if it did discipline unions like the EETPU, others would follow, `thus leading to further demoralisation's and weaknesses' (Interview Chairman Wales TUC). I asked the MSF official why he thought his union lost the recent Pirelli agreement to MATSA, the staff section of the GMBTU:

> We've looked long and hard at why we didn't get the Pirelli agreement ... I can only conclude we are a moral union, we defend our members' interests unashamedly ... Pirelli management were in search of the Holy Grail, they wanted an agreement that was utopian (Regional Officer MSF).

In response to my reply that yes, but nonetheless they still got it this official replied:

> Yes, but at what cost to the GMBTU, they have ridiculed themselves in the eyes of fellow trade unionists ... they have signed away the right to strike and agreed to all manner of changes in working practices ... the GMBTU say, look its only a piece of paper ... but I say if this is so, if this is all it is, why did you sign it ... it's more than this, you must also police it (Regional Officer MSF).

An ASTMS official argued he was :

> Very happy with single union agreements, particularly on green field sites. It is helpful to have them because the workforce can speak with one voice ... but in other industries it is helpful to have more than one union, particularly if you have a lot of hierarchical differentiation in work, i.e. different crafts, skill levels, demarcations, etc. ... However, all too many companies seek one union agreements without the facilities, or structure, to back up the agreement ... really all they want is a quiet docile union, or preferably none at all (Union Officer ASTMS).

A NALGO official stressed that:

> Our unions would never sign a no-strike agreement, or scab on another union like the EETPU did at Wapping (Union Officer Borough Council, Wales).

He argues that because NALGO operates primarily in the non-competitive public sector, it has not really had to deal with the issues surrounding single union agreements. As far as this official was concerned:

> A multiplicity of unions within a single plant, or across sectors, can undermine the unity of labour but, equally, single union agreements result in a danger of compromise with employers, complacency on union officials' part and lack of accountability to members. The system of employer tendering out of contracts is also undermining Trade Union solidarity as a whole (Union Officer NALGO).

An APEX officer believes single union agreements can be of benefit to the workforce, particularly the traditionally weak sections:

> For example, Clerks/Typists within a manufacturing company ... traditionally come the annual round of negotiations, the big unions representing production workers and craft workers would set the pace and often these girls were left behind ... or were negotiated for as an after-thought ... with single union agreements, the union can negotiate for everyone equally (Regional Officer APEX).

However:

> A strategy of go it alone negotiation, is bound to lead to actions like at Wapping ... single union agreements do have their drawbacks in terms of overall labour movement unity ... but what other way is there? (Regional Officer APEX).

Increasingly trade unions are embroiled in bitter disputes between themselves over negotiating and representation rights with employers and employees. The strategy of collective bargaining serves to undermine union solidarity and facilitate employers in pursuing policies of divide and rule. That union officials still cling so vehemently to existing collective bargaining procedures and feel fundamentally that there is nothing wrong in them highlights the scale of the problem facing British trade unions. Rather than acting collectively, unions are increasingly going it alone and this can only serve to weaken their ability to defend worker interests at a time when employers are introducing radical technological and organisational change.

Membership Patterns

British trade unions are in a crisis. Some unions are fighting for their lives, all are fighting to staunch the decline in membership. In 1981 there were 414 trade unions affiliated to the TUC today there are only 268 (Employment Gazette 1994). Since 1979 union membership has fallen by 4.2 million and now stands at 9 million the lowest level since 1946 (Employment Gazette 1994). This is the fourteenth consecutive fall in total union membership from its peak of 13.3 million in 1979 (AAS 1995, Government Statistical Office 1995). Union density among people in employment has fallen from 32% in 1992 to 28% today (Government Statistical Office 1995). David Metcalf predicts that by the end of the decade union membership will be below 20% density rates (Financial Times 1992), a drop from 55% since 1979 (Towers 1989). A number of reasons were cited by those union officials I interviewed, for this decline. These included the shift from an industrial to a serviced based economy, the increasing use of female and part time non-unionised labour, technological unemployment and the deregulation of various industries and services leading to a growth in subcontracting and the use of non-unionised labour.

Most of the unions recorded in 1994 were small; 163 (61 per cent) had fewer than 2,500 members and together accounted for just 1% of the membership of all unions. At the other end of the scale nine unions (just 3 per cent of the total) accounted for 60% of the total membership. Similarly the 20 largest unions account for 79% of all trade union membership (Employment Gazette 1994, AAS 1995).

Whilst most unions report membership losses, often dramatic, there are some who have been able to stem the loss through merger and amalgamation. UNISON, for example, is now Britain's largest union with some 1.5 million members. UNISON arose in July 1993 as a result of the merger of NALGO, COHSE and NUPE. Likewise in 1988 the AEUW-TASS and ASTMS joined forces to form one super union - the Manufacturing Science and Finance Union (MSF). Similarly in May 1992 the Amalgamated Engineering Union and the Electrical, Electronic Telecommunication and Pluming Union merged to form the Amalgamated Engineering and Electrical Union with 944 thousand members (Employment Gazette June 1994). However, the absolute number of union members shows a continued downward trend for both men and women, manual and non-manual, public and private sector employees (Employment Gazette 1994, AAS 1995).

Without amalgamations (where two or more unions join to form a new union) and Transfers of Engagement (where a union is subsumed by another union and thus loses its legal identity) all unions would have experienced sharp falls in membership. For example, TASS argue that although membership was greater in 1995 than 1979, this was due to a whole series of mergers it had undertaken, beginning with the National Union of Gold and Silver workers in 1981, then the Sheet Metal Workers Union, Pattern Makers Union, Metal Mechanics and Tobacco Workers Unions and finally its merger along with the AEUW and ASTMS to form the MSF:

> Without these mergers, real membership would have fallen some 40-50% due mainly to the dramatic contraction of steel, coal, shipbuilding and motor manufacture...and consequently our ability to defend members interests and have the weight to negotiate with employers would have been seriously undermined (Regional Officer TASS).

On the other hand, some unions, for example, BIFU have been able to expand membership without merger or amalgamation because the financial services sector has been expanding rapidly:

> Despite certain rationalisations and staff cuts like in the Midland Bank, there is still extremely high membership recruitment potential ... just take the four major clearing banks, let alone all the other financial institutions, within these four banks there are a possible 240,000 staff to recruit ... we haven't even begun to touch the tip of the iceberg ... (Regional Officer BIFU, see also BIFU 1987).

Most union officials blame recession, the run down and rationalisation of many industries and deflationary government economic policies for membership losses. A number were also worried that changed managerial attitudes - in particular the emphasis upon 'harmonisation' strategies and 'flexibility' were creating climates of fear and intimidation within many companies that was adversely affecting membership patterns:

> Since management here introduced its so called "harmonisation" policy we [the union] have been marginalised....management don't explicitly say it but its well known around here that union activists are seen by management as "undermining harmony"......they would rather have us out if they could...it makes it difficult to recruit members (Shop Steward UNISON).

Many union officials are also concerned about 'technological unemployment', although they have different estimates of the latter's impact on jobs and membership; some reporting that new technology has directly replaced, or undermined members' jobs, others reporting that it is not the introduction of new technology *per se* which is leading to membership losses, but recessionary pressures.

APEX, for example, predicts that some 20,000 office jobs were lost between 1978-1981 alone, as a consequence of the introduction of micro electronics into the office (Regional Officer APEX). NALGO argues:

> Information occupations, of which office work is a major one, include 65% of the working population. The scope for automation in office work, by introducing new technology, is vast and estimates of consequent unemployment of office workers vary between 25% and 40% (NALGO 1989:55).

Various unions also cite examples of micro electronic technology directly reducing the amount of labour needed to make a particular product, or provide a particular service. For example, it now takes only 11 hours to assemble electronic telex machines, compared to 75 hours to assemble a mechanical telex machine (ASTMS 1988). The only union in the survey which did not believe new technology would lead to further job and membership losses was the EETPU, who were confident that expansion of micro electronics and the skills required to service them would secure their members' interests. One EETPU official said he:

> Feels sorry for many of the other unions ... they are backing a losing horse, they simply don't have the skills demanded, whereas we do (Regional Officer EETPU).

However, this optimism seems to be contradicted by the fact that since 1979, the EETPU has lost 40,000 members - a fall stemmed only through merger with the AEU. For a union professedly based on new technology realism and the expansion of high tech industries it has also recently lost a number of potential agreements at high tech factories; for example, Pirelli's computer integrated manufacturing cable factory in Aberdare, South Wales, offered the single union contract not to the EETPU but to MATSU, the staff section of the GMBTU.

Whilst trade unions attempt to minimise the impact of new technology on job losses, through negotiating redeployment, re-training, and reduced hours, etc., the fact is that they have been largely unsuccessful. Recession, high unemployment and increasing anti-trade union legislation has enabled employers to introduce new technology, to increase labour productivity and reduce the size of the workforce, with little appreciable benefits to trade unionists. Unions like NALGO, are only too well aware of arguing, that even a `successfully implemented reflationary alternative economic strategy' will not bring back full employment, nor redress losses in overall union membership (NALGO 1989).

Future Direction of British Trade Unions

There is strong consensus amongst those interviewed that there will be a steady increase in the number of union mergers and amalgamations over the next decade. Old craft-based industrial unionism is seen to be declining along with the sectors that sustained it (Thompson 1995, McLoughlin & Gourlay 1994). Further, new technology, changing management practices and methods of work organisation, are seen to undermine traditional unionism based on craft, skill and demarcation. Increasing use of new technology, as in the print industry, or the latest computer integrated manufacturing techniques in manufacture, along with increasing drives towards flexibilisation, quality circles, and JIT are seen to require a `fresh', often `business orientated', `professional' and `enterprise union' union approach both to recruitment and trade union roles (Marsh 1993).

An official of the EETPU argues:

> There will be increasing moves towards greater amalgamation and concentration leading to the formation of fewer but more professional unions ... this will not be a smooth process, however, ... a lot of animosity and jealousy between unions will have to be sorted out before we see a strengthened union movement (Regional Officer EETPU).

According to an official of the TGWU:

> The effects of recession and mounting anti-trade union legislation are making it difficult for unions to keep their head above water ... certainly, there is also a real danger that future developments, particularly those involving single union no strike deals and acceptance of multi-flexibilisation and drastic changes in working practices, could reduce many unions to rubber stamps (Regional Officer TGWU).

For one particular union official unions may need to take on a more professional role, acting rather like a society, offering services to its members, for example insurance discounts, saving funds, discounted clothing and holidays, pension facilities etc., rather than emphasising their traditional class based roles:

> Trade unions must realise that they have to provide services to their members........to move away from overtly political roles...and to give members what they want and need, and to do this unions have to be of a critical mass and size ... generally the bigger the better (Regional Officer ASTMS).

An official of the NGA, however, disputes whether the trend towards greater union centralisation and concentration and an increasing emphasis upon service provision and status is a good thing:

> As the larger unions may be unable to voice the interests of specific workers, or understand the vagaries of a particular craft skill.....talk of dropping our traditional role as first line of defence for workers against possible victimisation by employers, and instead replacing it with debates as to who can offer the best services is a dangerous road to travel down...it could lead to the fragmentation, demoralisation and ineffectiveness characteristic of company unionism (Regional Secretary NGA).

NALGO foresee a growing climate of inter-union competition for a declining number of contracts, which will lead to increasing fragmentation of the labour movement:

> Unless the TUC act to discipline those unions who openly flout its ordinances ... and do more to foster a climate of collaboration and inter-union joint initiatives, rather than just sitting back and letting the forces of reaction push unions towards increased competition and fragmentation, i.e. single union no strike deals, multi-flexibilisation etc., then certain pernicious Japanese work practices and attitudes will take their toll (Regional Officer NALGO).

Whilst most unions see an increasing tendency towards amalgamation and do not particularly oppose it, an official of USDAW argues that he is opposed to the formation of fewer but more centralised unions:

> Amalgamation is entirely the wrong basis on which to decide union structures ... what could happen and what we are already seeing, is unions splintering and amalgamating for political reasons, for example, the recently formed MSF ... to construct a trade union structure, on the basis of political opinion, is outstandingly dangerous ... what we should be doing is looking at mergers in terms of industrial sense, rather than political compatibility (Regional Officer USDAW).

However, just the opposite view was put forward by an official of the MSF, who stresses that it is a question of survival that many unions amalgamate and that further:

> We are a political union ... I see a growing fracturing of trade unions along political centres, with certain unions amalgamating or occupying one position, be it centre or right, others occupying a more left position ... it is difficult to foresee who will go where, at the current moment, but certainly, I would not rule out a right block composed of unions like the EETPU and AEU, a centre block of unions such as the GMBTU and APEX and possibly the TGWU and a left bloc comprising unions like NALGO, NUPE, COHSE, and the NUM, etc. (Regional Officer MSF).

This particular official was almost alone in his presentation of the future direction of British trade unionism. The majority of those I interviewed argued that far from forming into definite political blocs, there was more likelihood of the union movement fragmenting, becoming de-politicised and more sectional. A particular sinister development for many trade unionists I interviewed was the shift towards `business' or `enterprise' unionism. Often associated with companies who had sought to relocate manufacture to `greenfield' sites. These companies were often seeking substantial concessions from trade unions and were perceived by a number of union officials I interviewed to be undertaking far broader and more sinister social experiments:

> These companies are not just seeking to impose restrictions on some of the most fundamental trade union rights...but they are seeking to engineer a new political climate within work.....they often use agencies and outside bodies to not only psychometrically test the workforce for passivity and docility, but to check that workers have no prior trade union experience, that they are compliant and malleable....overt displays of class solidarity are severely frowned upon by these companies (Shop Steward UNISON).
>
> The move towards greenfield manufacture and detailed employee record checking by companies is part of a new managerial culture aimed at creating `harmony' within companies.....management do not want to see politically motivated trade unions...they want passive docile workers and unions that will serve them in this aim. Greenfield sites enable firms to start afresh, to recruit from a wider social base, to overcome the problems of multi-union representation on many brown field sites and most importantly to pick virgin workers from virgin "new towns" (Union Officer TGWU).

The shift towards `greenfield manufacture' (Jessop 1989, Murray 1983, Gamble 1994, Handy 1995) and the increasing willingness of both employers and some unions to seek single union agreements, often with detailed restrictions on union practices and legal penalties attached to those unions that cannot police the `agreement' (Marsh 1993, McLoughlin & Gourlay 1994) is facilitating the growth of `enterprise unionism' and serving to fracture and undermine what little solidarity there has been within the British trade union movement (Hyman 1989). Whilst British workers are still, by and large, represented by industry wide unions with historically broader allegiances and more radical policies than Japanese style enterprise unions (Littler 1982, Halliday 1979, Japanese Ministry of Labour 1995) there is still nonetheless a decisive shift towards sectionalisation of the British trade union movement, a sectionalisation accelerated by the signing of `no strike' agreements, inter union competition for representation, and the lack of clear directive and a united front strategy on the part of the TUC.

Trade Unions and Change

APEX (1979), ASTMS (1983), NALGO (1989), BIFU(1986) and other unions, have produced a series of articles and guidelines concerning the introduction of micro processors, VDU's and computer aided drawing equipment, etc., to broader issues of job re-design, job content and evaluation of various forms of work organisation. However, Dodgson and Martin (1987) argue that unions on the whole have failed to establish firm priorities, or to distinguish between objectives which are attainable and those which are not.

A number of factors have conditioned the nature of the trade union response to the issues posed by new technology and changing working practices:

(1) as a consequence of the unevenness of technological changes and different managerial practices, both within and across different sectors of the economy, union response has surprisingly been uneven and varied (Jary 1987)

(2) the structure of individual collective bargaining imposes constraints on inter-union co-operation and solidarity (Wilkinson 1983, Batstone & Gourlay 1986, Marsh 1993)

(3) the role of the TUC, in particular, its reported inability to move beyond the policies envisaged in its 1979 report Employment and Technology, with its implicit attachment to tripartist structures which were firmly rejected by both the CBI and Government in October, 1980 (Dodgson & Martin 1987, Marsh 1993)

(4) the political backdrop of mounting anti-trade union legislation making it increasingly difficult for unions to act, a factor compounded by the consequences of recession and the disciplining effect this has upon unions' willingness and ability to successfully prosecute their members' interests (Dodgson & Martin 1987, CIS 1981, 1980, 1984, Hyman 1989, Marsh 1993)

(5) the changing structure of capital, not simply its concentration, centralisation and 'internationalisation' but also, and in consequence, its combined and uneven development both within and across the various branches of production. This poses problems for trade union organisation, not only in terms of unity, levels of control of internal labour markets, ability to deal with differing technological levels, etc., but also in terms of coming to grips with increasing calls from management for organisational changes associated with the over-used term 'Japanisation' (Ackroyd *et al* 1987).

Whilst most unions can agree on certain issues relating to new technology, in practice, the significance of various issues affects different unions differently. I have already noted how white collar unions, like APEX, were among the first to develop a strategy of implementing 'new technology agreements' as a means of dealing with issues arising from technological and work organisational changes; but other unions, for example, the GMBTU, have been slower to develop such a strategy, due in part to the fact that their members have not been so directly confronted with issues relating to new technology and job re-design and because of the 'difficulties and desirability of negotiating a formal strategy for a membership which is spread across diverse occupations' (Regional Officer GMBTU).

Equally, different unions do not necessarily attach equal importance to the various issues arising from new technology and job re-design. The AEU, for example, sees de-skilling as a major problem, particularly with the spread of numerically controlled machine tools, flexible work stations, computer integrated manufacture and robotics; but on the other hand, is not so concerned with reduced employment opportunities for women (Dodgson & Martin 1987).

The EETPU believes that the expansion of the electronics industry, coupled to its 'realistic union policy will secure and even strengthen its members status and prevent de-skilling' (Regional Officer EETPU). ASTMS on the other hand is worried about limitations on the promotion prospects of certain of its members, for example, draughtsmen, and lower management, etc., as a consequence of both technological change, i.e. CAD in the drawing office, and work reorganisations involving `rationalisation' of organisations through the use of both computing technology and new working practices, such as QC circles, which can tend to undermine traditional supervisory and management structures (Regional Officer ASTMS). Other unions, including the NGA, have sought to get agreement with employers and other unions in the print industry in order minimise the damage caused to NGA members through the technology of direct inputting. However, SOGAT has not sought agreement in the belief that their members will benefit from the introduction of direct inputting and subsequent loss of NGA members' jobs (TUC 1987, Gennard & Dunn 1983). The TGWU is particularly concerned about the increase in managerial control resulting from changes in working practices such as multi flexible working, JIT, and QCs, as can be seen in its rejection of Ford's terms at Dundee (Regional Officer TGWU; Western Mail 1988).

The variety of economic sectors unions are located in profoundly conditions their attitude and response to issues relating to technological and organisational changes tending to mitigate against the formation of a coherent united front strategy for the union movement as a whole. The problems emerging can be seen quite clearly in the polemic between the AEU and TGWU concerning Ford's conditions for proposed investment in Dundee. The AEU accused the TGWU of being `backward looking', the TGWU for its part, pointed out that the proposed changes Ford were intending to implement - multiflexibilisation, weakening demarcation, introduction of QC circles, and JIT - will undermine workers bargaining power, not only in the new plant but throughout Ford's operations in the UK (Regional Officer TGWU, Western Mail 1988).

The structure of individual collective bargaining has itself caused difficulties for the trade unions, given the trend on the part of many employers, for single union, no strike packages, encompassing comprehensive restructuring of work, breaking down of job demarcation and increasing calls for flexibility and the use of non-craft labour. As one union official put it:

> Unions have become more like businesses, each trying to recruit as many members as possible and, of course, as a consequence, each entering into competition with the others - a process exacerbated by employers' increasing use of the tendering out system, particularly on green field sites (Union Officer GMBTU).

None of those interviewed denied that fierce inter-union competition took place to secure the prize of union recognition at these sites. As one official said over Nissan:

> We were forced to parade before prospective employers like beauty queens and if the situation arose again in the future I suspect we would all be on parade again (Union Officer SOGAT).

The problems this is causing for the Trade Union movement in terms of solidarity and ability to represent workers interests cannot be over-emphasised.

Whilst most trade union officials argue that for many years individual unions have sought `sole recognition' agreements, the nature of these agreements, along with the ground on which they are taking place, is changing rapidly. Many employers are seeking to use changed economic and political climates to push through working and industrial relations practices that only several years ago would seem unthinkable. For example, Pirelli closed down its cable manufacturing plant in South Wales, laying off the entire workforce, only to re-open a new plant on the same site two years later. This plant, heavily funded by the Welsh Development Agency, represents the pinnacle of up to date technologies and managerial practices. An integral part of the company's adoption of these practices was the signing of a single union, no strike deal, encompassing radical organisational changes in working patterns, career progression, demarcations and modular working with MATSA, the staff section of the GMBTU (South Wales Echo 1987, Pirelli 1987).

The dispute at AB Electronics at Abercynon further highlights the breadth of changes taking place. AB management decided that as part of its switch to `surface circuit board' manufacture, as well as its future ability to produce to consumer specification, greater flexibility of labour and ending of traditional job demarcations was required. To achieve this, AB tore up its old multi-union agreement and declared it sought only single union representation at the plant. Three out of the four unions at the plant rejected AB's proposals. The AEU, however, said it would accept AB's terms, thus leading to bitter dispute among the unions concerned.

Even in relatively favourable times of economic boom and `full employment' the structure of collective bargaining between individual unions and employers did very little to enhance overall trade union solidarity and inter union co-operation (Pimlott 1991, Marsh 1993). In a climate characterised by over-accumulation, intensified market competition and increasing internationalisation of capital, traditional structures of collective bargaining are becoming more and more obsolete and incapable of securing workers interests (Beaumont 1995). The policy of each individual union, out to secure the best deal it can get, may prove, ultimately, self defeating, given the changed political and economic climate in which these new deals are being won. Certainly, as many union officials argue, concessions have been made to employers which five or ten years ago, would have been unthinkable. Not only has the practice of each individual union going it alone led to increased inter-union competition for a declining number of contracts but it has also led to an abandoning of concern on the part of many trade unionists with issues relating to the design of work, increased part-time working, equal opportunities for women, or reduction in the working week. Too many unions are now concerned to win a contract at virtually any cost. The question must remain as to just how far the union movement can venture down this concessionary road, without losing credibility. Even where unions win contracts, there is no guarantee that they will be able to maintain, or expand membership. Unionisation of the workforce at Nissan in Sunderland, where the AEU has sole negotiating rights, has recently fallen to only 16% of the workforce; the AEU being seen by many as little more than a `rubber stamp' for the company (Regional Officer MSF).

Certain union officials argue that the TUC only has the power its constituent members give it and that, given the reality of a long history of collective bargaining, with each union more or less going it alone fiercely conscious of its independence, it would be difficult for the TUC to take any real directive or disciplinary action against unions such as the EETPU which openly contravene its ordinances and policy. Other trade unionists disagree and believe the TUC could, and should, take a more directive role, not only in relation to disciplining unions like the EETPU but also in providing information, guidelines, organisational support, and directives over issues relating to new technology and work re-design. Two officials and several shop stewards went even further, arguing that the TUC's lack of action over these issues, as well as its refusal to organise against anti-trade union legislation and various aspects of government policy, was little short of `scandalous' (Interviews with MSF and NALGO Officers and APEX and NALGO shop stewards).

The 1979 TUC policy document Employment and Technology, of course, does little more than reflect already existing union practices, merely suggesting that unions should attempt to deal with the issues relating to new technology and changing working practices through the establishment of NTAs. The document presents guidelines and recommendations, and documents the dangers to trade unions that may arise from the careless introduction of technology. As a whole, however, it represents little more than a 'populist' encouragement of investment in new technology and its dispersal throughout the economy. Given the traditional role of the TUC, it is left to individual unions to develop their own strategies for securing effective involvement in the design process. Consequently, a very uneven level of awareness of the politics of design exists among the various trade unions. Unions like the MSF, APEX, ASTMS and NALGO are in quite favourable positions to negotiate changes, having members who are often key personnel in the process of design. Thus, for example, one software engineer I interviewed who was in the MSF argued:

> Generally our members are in a good position to negotiate with management over new technology because we often are more aware of its consequences and implications than they are ... and certainly at this site we have influenced the choice of equipment purchase and software used in a variety of systems ... and I think on the whole our involvement has been welcomed by management (Software Engineer, US Electronics Company, Lothian, Scotland).

Other unions, however, fare worse. All, however, have to look to their own limited resources and research expertise, to provide themselves and their members with information concerning the issues involved before developing appropriate strategies (Clark *et al* 1988, McLoughlin & Clark 1994). Two unions which assessed the situation and developed specific strategies to meet it are the AEU and EETPU. The latter, runs its own training colleges, designed to win employer support for retraining electricians in new skills. The former operates a similar programme but through liaison with local technical colleges, businesses and the union. Both unions seek to update their members' skills, in order to be able to keep abreast of technological developments and secure their craft status within the division of labour. Notably, both unions are also pursuing an active policy of trying to recruit all employees at a given plant, irrespective of craft (AEU 1988, EETPU 1987).

The CBI (1994) suggests that agreement to the introduction of new technology has involved the removal of restrictive practices, the adoption and extension of shift working, reduction in numbers employed, increase in part-time female labour and the introduction and extension of piece rate and incentive payments and other productivity improvements. McLoughlin and Clark (1994) argue that both the adoption, and content, of technology agreements have been limited compared to original TUC objectives. They found that only a small number of unions, mainly white collar, actively used technology agreements as part of a general policy. Batstone and Gourlay (1986) found NTA's and TUC negotiating guidelines were of little, or no benefit, to shop stewards in dealing with specific technological changes, whatever influence worker representatives had on the process of change, being related more to traditional control of internal labour markets than to specifically developed strategies relating to the introduction of new technology, or new working practices.

Marsh (1993), Hyman (1989) and Knights and Willmott (1988) argue that the concern of many employers is to keep trade unions confined to traditional bargaining areas. As such, they prefer consultation rather than bargaining *per se*. Ironically, the WIRS (1990) survey indicates that management are reporting more consultation with employees over the introduction of new technology. However, the key word is consultation and not negotiation as more and more organisations make direct appeals to the workforce in an attempt to subvert traditional trade union negotiating machinery (McLoughlin & Clark 1994). Management is asserting its `right' to select the particular technology, its detail specification, the way it is to be used, to what end and the way work is to be organised around it (Hyman & Mason 1995). Giles and Starkey (1987) argue that many employers are making use of anti-trade union legislation and the disciplining effects of recession on the working class to introduce new technology and new methods of work organisation much as they please. The increase in part-time and multi-flexible working, QCs and JIT, along with the break up of traditional job demarcations and the decomposition of existing pay and salary structures reflects firms attempts to reduce costs, tied up capital, improve quality and increase labour productivity in an attempt to maintain and increase profitability.

> I've seen the company alter demarcations on the line several times in as many years ... full time are replaced with part-time and students ... you've got a new category of maintenance ... we no longer have electricians, fitters, mechanics and the like ... likewise jobs on the line have been downgraded ... we've taken pay cuts and anyone can do this job ... it takes hours to learn ... that's all ... through it all they've been too frightened to resist ... any job is better than the dole...and the thing is that even to get a job as a packer you now have to go through a screening agency and sit specific psychometric and arithmetic tests (Shop steward AEU, US Electronics Manufacturer, Scotland)

The Trade Union Research Unit cites four reasons why trade unions might not be able to resist new moves towards changing working practices:

(1) managers might appeal to workers over the heads of union representatives.

(2) Such an appeal may carry weight because for groups to be pushed to the periphery, this might be preferable to redundancy, and for groups to be retained in the core, the improvements in conditions of employment, wages, etc., might be preferable.

(3) Management can present these moves as the simple extension of existing practices, i.e. use of temporary workers.

(4) It could be presented as part of a new technology/security agreement which is likely to be attractive to existing employees (Trade Union Research Unit 1995).

With unemployment levels high and with sweeping changes in social security and housing benefit legislation, designed to foster insecurity, offers of job security allied to changes in working practices, however unpalatable, are often too tempting to resist:

As Dodgson & Martin argue:

> It is perhaps a sign of acquiescence, or indeed fatalism, that the TUC's Employment and Technology Committee - composed of representatives of major interested unions, supported by TUC research staff - has not met since November, 1984 (1987: 36).

Under the impulse of recession and economic stagnation, a new `realism' has swept the British political scene. Bitter memories of the `winter of discontent' under Callaghan, coupled to the Labour Government's attacks on trade union bargaining power, at a time of rising inflation, along with Labour's inability to resolve the economic crisis, or deal with rapidly rising unemployment, facilitated a political shift to the right.

This shift is occurring, in large measure, due to the failure of parties of power to manage the contradictions of the capitalist mode of production (Coats 1980, Marsh & King 1985, Hyman 1989, Marsh 1993). As Callaghan made clear in 1976:

> We must make a success of the mixed economy by adhering to an industrial strategy worked out and agreed by both the TUC and the CBI, which aims at giving *absolute* priority to industrial needs, ahead of even our social objectives (cited Coates 1980: 35).

Giving `absolute priority to industrial needs' meant implementing Phase I, II and III of the Social Contract, undermining trade unionism, in particular its most militant sections, and cutting back on non-productive, i.e. unprofitable capital expenditure (CIS 1984). Yet the basic malaise of the economy remained unresolved, the weakness of British manufacturing being reflected in a 70% increase in imports between 1973-1974 (Coats & Hillard 1986).

In 1980 Keith Joseph, prioritised the Conservatives key areas of attack:

> The visible signs of Britain's unique course as it slides from the affluent western world towards the threadbare economics of the communist bloc are obvious enough. We have a demotivating tax system, increasing nationalisation, compressed differentials, low and stagnant productivity, high unemployment, many failing public services and increasingly growing public expenditure; an obsession with equality and pay, price and dividend controls, a unique set of legal privileges and immunities for trade unions and finally, since 1974, we are top of the Western league for inflation, bottom of the league for growth (Joseph cited by Gamble 1981: 132).

Under the guise of an attack on inflation the Conservative Government proceeded to isolate, discredit and fundamentally weaken the trade union movement, as well as implementing a series of measures to tackle the problems outlined by Keith Joseph above (CIS 1984, Hyman 1989, Marsh 1993).

For its part, the TUC and trade union movement as a whole were wholly unprepared for what was about to befall them. Indeed, the TUC is still arguing for policies similar to those advanced in 1979, namely reflation of the economy, selective import controls, restrictions on capital export and increased investment in public services. With its strong attachment to tripartite structures fuelled by its experience of two decades of post war boom and working within governmental, business and public institutions, it has been unable to seriously counter Conservative Party calls for increased efficiency, productivity, reduced public spending and the need to reduce inflation. Trade unions as a whole are marginalised and weakened further by the rapid rate of job and membership losses accompanying rationalisation and closure of many plants, factories and offices.

That many workers and rank and file trade unionists are prepared to fight for jobs and services is clearly evident in the case of metal, steel, water, automobile and mine workers' struggles. These struggles were, nonetheless, isolated - not only by Conservative strategy and legislation (CIS 1980, 1984, Hyman 1989), but also by the TUC and Labour Party's own lack of directive and initiative (Hyman 1989, Marsh 1993, Beaumont 1995). Whilst many Trade Union officials and Labour Party leaders proved unable and unwilling to `rock the boat', Conservative governments proceeded to introduce a whole series of measures designed to curb trade union power and aid employers in restructuring industrial relations. The 1980 and 1982 Employment Acts profoundly shifted the legal ground on which trade unions operate. These Acts were further buttressed by the 1989 Employment Act and the Trade Union and Employment Rights Act of 1993. Unions must now forego many traditional forms of action including solidarity strikes, blacklegging or secondary picketing. Combined, this legislation has also made it easier for employers to sack workers on strike, undermine the closed shop agreement and encourage the use of non-union labour, and very importantly, unions are now liable to pay civil damages for any industrial action undertaken. This legislation alone removes one of the most important immunities for trade unions. There is now no right to strike in Britain, merely some defences and immunities striking workers can use if employers take them to the courts (Hyman 1989, Weston 1992, Goodhart 1992).

Accompanying direct anti-trade union legislation are a whole series of measures from abolition of the low wage councils, changes in social security, unemployment and housing benefit entitlements, to cut backs in public services, transport, nursery provision, education and health which act to weaken working class resistance and solidarity (Hyman & Mason 1995, Regini 1994). It is against this background of recession, rising unemployment and political attacks on working class rights and living standards that trade unions have had to deal with employers attempts to introduce new technology and changing working practices. As an officer of ACAS argues:

> It is no coincidence that the signing of single union no strike deals and acceptance of many new working practices, such as QC Circles, flexibilisation, etc., have taken place when they have...employers are feeling confident and unions are on the defensive (Regional Officer ACAS).

It is interesting to note that employers, management and consultants are emphasising the need for greater 'harmonisation' and 'flexibility' precisely at a time when the economic and political climate is predicated upon intimidation and coercion (CIS 1984, Giles & Starkey 1987, Marsh 1993). Management are seeking to 'enhance' employee commitment and create new forms of 'employee participation' in ways which undermine and further weaken institutionalised collective bargaining agreements (Hyman & Mason 1995, Beaumont 1995). The vacuum created by the collapse of these traditional bargaining agreements increasingly is being filled by a management keen to 'break with bureaucracy' and keen to emphasise the unique contribution of the 'individual employee' to the organisation (Beaumont 1995).

With the rationalisation of industry and services in the face of both over production, intensified competition and tighter public expenditure, with the continual rise in the ratio of industrial inputs away from labour and towards capital (Employment Gazette 1993) and with the new `high tech' industries unable to generate sufficient employment, it is little wonder that many trade unionists are not hopeful about the future. Where firms are restructuring and re-investing, for example, Pirelli at Aberdare in South Wales or Vauxhalls at Halewood, they are doing so on the basis of new technology and new working practices specifically designed to reduce the quantity of labour needed whilst at the same time increasing productivity.

Faced with the fear of unemployment, bludgeoned by an ideological barrage of competitiveness and anti-trade unionism, lacking a TUC capable of organising successful resistance to Government and employer-led offensives, it is unsurprising that many workers are being forced into accepting changes in working practices and conditions which several years ago would have been unthinkable. Along with the restructuring of capital, many firms are attempting to restructure labour markets and introduce new technology and organisational practices. Some union officials argue that companies are seeking to create dual labour markets with a central core of full-time, skilled, relatively highly paid workers operating and servicing new technologies whilst a mass of semi-skilled or unskilled labour with little security and poor wages, serve as a reservoir of temporary and casual labour to be brought into the production process as and when market demands. As in Japan, this will pose large problems for both union solidarity and the ability of unions to recruit members (Haliday 1975, Sayer 1986).

As British, European, American or Japanese firms look to organisational changes and new technology, to improve their competitive position, organised labour is put under increased pressure to accept the new discourse of 'harmonisation' and 'work flexibility' (Marsh 1993, Beaumont 1995). Indeed, the idealised model of the happy Japanese worker and of 'corporate familyism' is becoming a new discourse in managerial circles - the model to which all should strive. But what happens when, in part or in total, the model is attained? Research into industrial relations at various Japanese firms shows that all is not rosy. Compulsory overtime - often unpaid - increased working hours and intensity of work, reduced break times, numbing uniformity, ideological bludgeoning in company values and culture, excessive vetting of employee records, fierce competition within and between quality circles and work teams, produce their own problems and anxieties (Hague 1987, Turnbull 1987, Ackroyd *et al* 1988). How successful various companies efforts will be in pushing through and maintaining these practices is open to question, as is employee acceptance of, and attachment to, them. If these practices become widespread, it simply means the competitive struggle between firms is lifted to a new and higher plane, obviously the question then is what further measures will management be able to adopt to secure further competitive advantage. Management itself may experience crisis, not least because much of the information technology revolution is directed at rationalising middle management posts (Handy 1995). Certainly, one union official was keen to point out the implications for management of their attempt to get workers to swallow the 'harmonisation and flexibility' medicine:

> We are told if only we make sacrifices now ... if only we agree to be flexible ... if only we agree to put in more effort ... give a little more ... all will be well ... but what if it isn't? What if after making all these sacrifices workers are no better off and firms are still struggling to survive ... hell will break loose and management and unions will have to face up to this ... it will be an ideological crisis of immense magnitude (Regional Officer GMBTU).

Perhaps it might be useful to understand managerial moves towards `harmonisation' and new `flexible' working practices as an attempt to overcome one of the central contradictions of the capitalist mode of production - namely, its tendency to socialise the forces of production in order to better harness and utilise labour-power - to gain its consent (Burawoy 1979) - but at the same time expressing its inability to do so without violating the laws of private accumulation and appropriation on which that mode of production is predicated (Marx 1977).

Summary

Union involvement in the systems design process in the UK is far more circumscribed than that of the collective resource approach in Scandinavia. Despite union officials positively encouraging investments in new technology, their deterministic views of technology tend to downplay its significance and inhibit their involvement in the process of system design. Unions are largely excluded from this design process by management and have been unable to achieve even the TUC (1979) guidelines on new technology. A variety of factors are responsible for this including union officials perceptions of what constitutes legitimate spheres of interest. Issues relating to the choice of technology and the design of work are usually seen as management's prerogative. Union involvement in the design process tends to be confined within existing collective bargaining procedures to resolve working details such as job demarcations, staffing and retraining. Unions that have more input into the design process tend to be those whose members occupy key positions *vis a vis* new technology implementation; these tended to be white collar unions like APEX or the AEUW TASS. These unions are also able to achieve the highest number of NTAs.

The overwhelming majority of union officials believe the current governments' 'free market' philosophy is both misguided and damaging to the long term interests of British manufacturing, arguing that it leaves business vulnerable in the face of state supported foreign competition and creates a climate of fear and distrust which inhibits management from tapping into valuable employee knowledge thereby undermining the smooth and efficient restructuring of manufacturing.

There is general consensus that the TUC has not done enough to make individual unions aware of the issues relating to new technology and work redesign. TUC guidelines on new technology are seen as dated and ineffectual. Likewise there is heated debate amongst the various unions concerning single union agreements. Most union officials argue that they are not a bad thing in themselves, but that their changing 'content' is controversial, e.g. no-strike clauses, agreement to multiflexibility, ending of job demarcations.

Most unions recognise that new technology is being used to rationalise work processes but that it is difficult to isolate the technology *per se* as a source of unemployment and falling membership when other factors like business closures and changed political climate, managerial culture and work practices could be playing an equally significant role.

Finally, there is some disarray regarding the future direction of British trade unionism. Some officials believed that the trend towards amalgamation and merger would continue - leading to the formation of `super unions' and increased potential for representation of members` interests. Others pointed to the increased inter-union competition for contracts which could lead to the formation of distinct `political blocks' within the union movement. All unions, however, with the possible exemption of the EETPU, were uneasy about the future and concerned with government legislation and its adverse impact on trade union rights and trade unions` ability to prosecute their members interests. Running a close second was their concern over changes in working practices and work culture, such as management emphasis upon `harmonisation' and quality team strategies, which were seen by many as attempts to by-pass traditional trade union bargaining procedures and practices.

Engineers and Systems Analysts:

Class and Work

Introduction

In previous chapters I have argued that notions of capital interest are vague and belie the complexity of interest groups, coalitions and factions that have an impact upon the design process within modern corporations. Each of these may try to shape any particular system to suit their own particular objectives. In focusing upon the work, values and methods of engineers and systems analysts (Chapters 2,3 & 4) I have highlighted how engineers and systems analysts do not automatically or simply reproduce the interests of capital within the design process, but rather bring to bear their own personal experience, values and world views some of which may act to reinforce particular dominant notions of efficiency or rationality and some of which may serve to question them. I have argued that engineers and analysts have degrees of autonomy over the process of design and the types of systems that get built. This autonomy is, however, relative and in practice has seldom been used by engineers and analysts to assess critically the systems they build. I have offered several explanations of why this might be so, for example, in terms of engineers' and analysts' education and training, the tools and methods they deploy and the values they hold. To elaborate on the possibilities of engineers and analysts exercising this autonomy in a critical fashion I examine their class background to see if this colours their approach to design - through, for example, placing them in an antagonistic position to specific groups of employees or through making them more receptive to certain kinds of culture, theory or practice.

Whilst engineers have often unwittingly been lumped under the heading middle class (Poulantzas 1978, Ehrenreich 1979, Abercrombie & Urry 1983), there has been little attempt to specifically analyse the class position of systems analysts. At a general level they are perceived as `professionals' (BCS 1988) and by association middle class - occupying a distinctive place in the social division of labour exercising responsibility and possessing polyvalent skills - including managerial (Friedman 1989). In this chapter I assess a number of different attempts to theorise the class position of engineers and systems analysts. My argument is that much of the theoretical debate on the 'middle class' is formal and ascriptive[1] and that the term middle class ends up being used too indiscriminately - for example, to cover all `white collar', 'professional' or `non-productive' workers, as though these are clearly defined discrete social entities, with corresponding forms of class practice and consciousness. I argue that engineers and systems analysts by and large are part of the `collective labourer' and that the concept 'collective labourer', unlike the concept 'middle class', captures the heterogeneity, contradictory and changing relationships different sections of this labour experience at different historical conjunctures. The concept of 'collective labourer' is intimately tied to the development of capitalism and the unfolding of the accumulation process, whereas, in conventional usage, the concept `middle class' is static and has no necessary relation to the broader process of capitalist accumulation and reproduction[2]. Finally, I highlight engineers' and analysts' different perceptions of class and the ways in which these have an impact not only upon their designs but upon engineers' and analysts' conceptualisation of their own labour and its product.

Relational and Gradational Models of Class

Nichols (1986) argues that an entire history of political sociology could be written on the theme of the `new middle classes', with recent declines in manufacturing and an apparent increase in mental, rather than manual labour, providing a general impetus to the theorisation of `intermediate strata' in most advanced capitalist societies.

In trying to identify and make sense of the 'middle class', particularly the huge mass of 'white collar' workers and 'professionals' that emerged with the growth of monopoly capitalism and the increasing activity of an enlarged state and organisational apparatus in the developed capitalist economies, many theorists, both neo Marxist and neo Weberian, have, inadvertently, pursued an analysis which stipulates class in terms of its own inbuilt divisions or imposed categories, for example, skilled, unskilled, productive/non-productive, etc. Classes are then broken down in pyramidal fashion according to a set of shared descriptive criteria - type of work, income levels, voting behaviour, demographic position, attitude to race, sex, police, etc. This approach, whilst enriching our understanding of different social groups at particular moments in history, lacks dynamic. In effect, no sooner has this ascriptive sociology defined a certain social group in a particular way (for example, Lockwoods (1966) 'traditional', 'deferential' and 'privatised' worker) than history and events move on and social relations change;

meanwhile, theorists are still busy gathering the latest up to date statistics on income, voting behaviour, attitudes and lifestyles, so as to revitalise their ahistorical analysis.

Thompson (1979) argues that what is needed to make sense of the above ever changing empirical findings is a relational analysis of class. Thompson argues that the notion of class entails the notion of historical relationship:

> Like any other relationship, it is a fluency which evades analysis, if we try to stop it dead at any given moment and anatomise its structure ... the relationship must always be embodied in *real* people and in a *real* context ... class is not just a relation but a bi-polar relation, the dialectical relationship of opposites ... We cannot have two district classes, each with its independent being, and bring them together into relationship with each other ... class happens when some men feel and articulate the identity of their interests between themselves and as against others whose interests are different and opposed to theirs (1979: 9-10).

Without such analysis, Thompson argues all kinds of anomalies and contradictions emerge, leading to a curiously static presentation of class[3].

According to Thompson, there is today, an every present temptation to suppose that class is a `thing'; for Thompson, this error vitiates much latter-day Marxist writing, but is contrary to Marx's original methodology which stressed the relational aspect of class. For Marx:

> The separate individuals form a class only in so far as they have to carry on a common battle with another class ... these individuals find their conditions of existence predestined, and their position in life and ... personal development assigned to them by their class and become subsumed under it (1969: 714).

This notion that groups within society are the bearers of deeper social relations, which may act behind their backs to condition their practice, is central to Marx's analysis. Thus Marx argues:

> The specific economic form, in which unpaid surplus-labour is pumped out of the direct producers, determines the relationship of rulers and ruled, as it grows directly out of production itself and, in turn, reacts upon it as a determining element ... it is always the direct relationship of the owners of the conditions of production to the direct producers - a relation always naturally corresponding to a definite stage in the development of the methods of labour and, thereby, it's social productivity - which reveals the innermost secret, the hidden basis of the entire social structure, and with it the political form of the relation of sovereignty and dependence, in short, the corresponding specific form of state (1962:772).

Clearly, these texts have been interpreted as turning politics into an epiphenomenal activity and ascribing to the economic a totally determining role. Cohen, for example, argues that:

> The proletarian is the subordinate producer who must sell his labour power in order to obtain his means of life (1978: 73).

Marx maintained the centrality of analysing class, as a relation - 'the separate individuals form a class *only* in so far as they have to carry on a common battle with another class' (1969: 714). Cohen, however, contents himself with defining class specifically with reference to the position of its members in the economic structure (1978: 73). Whilst

Cohen stresses that property relations locate people in the class structure his interpretation of Marx is, nonetheless, `economistic'. Marx states that whilst the economic form determines the relationship of rulers and ruled, the latter, in turn, react upon the economic as a determining element. This is not contradictory but central to Marx's dialectical method. Cohen's formulation, that the proletariat encompasses all 'subordinate producers who sell their labour-power', is too vague and does not really advance the perennial structure - agency debate stemming from Marx's notion of a 'class in itself', and a 'class for itself' - namely, why do some sections of the subordinate producers perceive their interests to be different from others?

In focusing upon the mode of production and the production of surplus value, in particular, Marx sought to highlight the exploitative nature of capitalist social relations, to demonstrate how the production of surplus value was contingent upon one class appropriating the unpaid labour of another class and how this, in turn, manifests itself in a struggle both within and outside the factory, over the division of the working day between `necessary' and `surplus labour' - wages and profit, a fact which led Marx to focus attention on what he identified as the two main classes in capitalist society - bourgeoisie and proletariat[4].

Marx's focus on the production of surplus value and his utilisation of an abstract pure model of capitalism does not, however, provide a detailed analysis of the 'middle classes', or their relation to other classes. Weber (1964), on the other hand, is particularly concerned with the composition of the 'middle classes'. Weber drew attention to forms of stratification other than class, notably status and ethnic stratification. His sociology of class starts with two `basic categories of all class situations' namely property and propertylessness, but differentiates a large number of both positively and negatively privileged classes with reference to education as well as property (Weber 1961: 182). Weber distinguishes between two types of positively privileged classes, namely ownership or property classes and acquisition or commercial classes. The latter includes all those who possess goods, services and skills that can be offered on the market. Weber also distinguishes three types of `negatively advantaged' classes, namely, the `unfree', the `declassed' and the `paupers' and three types of negatively privileged commercial classes, namely, `skilled', `semi skilled' and `unskilled workers' (1968: 304). In between both types of positively and negatively privileged classes, Weber noted the existence of various middle classes - `peasants, craftsmen, public and private officials, liberal professions and groups of workers with exceptional credentials or skills' (1968: 304). For Weber a social class `makes up the totality of those class situations within which individual and generational mobility is easy and typical' (1968: 302). Weber stressed that class advantages flowed from knowledge or skills and that there was a need to distinguish between class situations and status situations (Weber 1961).

According to MacKenzie:

> Academic sociologists have almost universally recommended Weber's approach, as both appropriate and realistic, for an understanding of the complexity of class

> differences to be found in late twentieth century capitalist society (despite the fact that) ... as a theory of class relations and, in particular, of class boundaries, Weber's approach is at best, incomplete, at worst, superficial; for at the end of the day, his identification of four social classes is merely descriptive (1982: 66).

Goldthorpe extends Weber's analysis into a seven class schema (1987, 1992) in which individuals are accorded specific class places largely in terms of the credentials and skills they posses rather than whether or not they stand in specifically antagonistic relationships to each other. This kind of gradational definition of class typically involves, as Edgell (1993) points out, a trichotomous structure characterised by many divisions, each of which is considered higher or lower than the others. The obliteration of antagonistic relations between gradational levels within the Weberian model enables writers like Goldthorpe to lump together heterogeneous groups into one class - the service class. Yet, as Abercrombie and Urry have argued, there are problems with Goldthorpe`s presentation of the service class:

> First, it is an aggregation of occupations rather than a class united by the performance of services for a capitalist or within a bureaucracy. Secondly, it is not an intermediate class but it is rather at the top of the hierarchy (1983:32).

Weberian analysis invariably enhances the significance of the service class at the expense of the capitalist class. Further, assigning routine white collar employees and small proprietors to a broad class labelled `intermediate', is contradictory and confusing. For example, some small proprietors may be in a very precarious class situation, likewise compared to many private sector bureaucratic employees, some small proprietors may be in a very advantaged class position.

Weber's inability to explain why certain individuals and social groups consistently end up at certain points on the power hierarchy is a major limitation and one which prompted Weber to acknowledge the importance of property in class formation. Weber roots his analysis of class in an analysis of the market which sees class as derivative of the distribution of market power which is seen as determining life chances and class position[5]. For Marx, the conflation of income categories with social classes masks class struggle between the bourgeoisie and working class, replacing it with a multitude of intermediate groupings delineated in terms of income vying for improved market position.

Finally, Weber ties class formation to an onward march of bureaucratisation and rationalisation (Weber 1968) but offers little theorisation of who is carrying through this process and why. Like Burnham's (1962) managerialist and bureaucratisation thesis, Weber's class model conflates social formations by abstracting their specific class content and replacing it with an almost unlimited gradational content of credentialists contending on the power hierarchy. The problem with this approach is that it presents history in teleological fashion as the unfolding of the 'rational ideal', the onward march of 'progress'. This analysis fails, to explain, for example, why processes of rationalisation, routinisation and de-skilling of work take place; and it offers a limited theory of crisis and class struggle.

Boom, Bust and Reassessment of Class

The post war boom informed academic and working class conceptions of capitalism; rising employment and living standards seemed to confirm the view that capitalism was essentially stable. Between 1945 and 1962 average weekly wage rates rose 90% and average earnings by over 130% (Chivers cited in Roberts 1966). The considerable increase in labour productivity led to a tremendous rise in output and allowed the working class to obtain more use-values for its wages[6].

Full employment, subsidised housing, more extensive social security and improved health and welfare facilities in the 1950s - 1970s coupled to an unprecedented consumer credit expansion in the late 1960s increased material standards of living and seemed to confirm the benevolent face of the free market, particularly, when contrasted to the austere images of the Soviet Union, fostered in this Cold War period. The Conservative Prime Minister in Britain told us, 'you've never had it so good'. Meanwhile, intellectuals in the British Labour Party, like Crosland, Strachey and Jay, were arguing that Labour, as a `national party', should cut its ties with the working class and appeal to an all class alliance. Too close an identification with the working class was regarded as an electoral liability. The document, Industry and Society, adopted at the 1957 Labour Party

Conference, accepted the need for an all class party (Milliband, 1972). Membership of the Labour Party fell 20% between 1952-1965 and that of the British Communist Party from 56,000 in 1942 to 32,000 in 1962 (Pelling 1975). Daniel Bell (1969) proclaimed the 'end of ideology', asserting that we were moving towards a 'post industrial society', of entirely different complexion to the one that characterised the industrial era; namely, it was managerial and technocratic in structure and social classes had become fragmented into clusters of overlapping interest groups with an end of polarised politics.

Trade union organisation however, was strong throughout the period, a strength shown in the capacity of the labour movement to counter the offensive of the state once the boom began to tail off in the late sixties. Workplace organisation was strong and the labour movement confident and combative - reinforced by virtually full employment (Hyman 1989, Pimlott 1991). Unions reacted to government offensives on pay restraint and policies directed against the closed shop and union rights with spirit and determination, reaching a peak of militancy in the early 1970s. This was the period of the release of the Pentonville dockers, the closure of Saltley Gates by thousands of miners and engineers and the rout of the Heath Government; but even in this period, the political weakness of the working class was evident. The bourgeoisie was able to achieve a number of partial victories to be consolidated under the 'Social Contract', the imprisonment of the Shrewsbury Pickets, legislation against secondary picketing and the later monetarist drive of the Conservatives under Thatcher (CIS Anti-Reports, 1981, 1984, 1986).

To make sense of this political weakness and to counter theorists like Bell who were arguing Marxism was defunct, a whole school of sociologists and radical Marxists, in Britain and abroad, began to examine the class structure in more detail, in a process of critique and reassessment (Newby 1979). Many theorists believed the `Proletarianisation thesis' to be inadequate, or in need of serious clarification, arguing that far from there being a polarisation of classes under capitalism either, (a) the reverse had occurred and the transition to monopoly capitalism had generated other classes; (b) that the proletariat was a declining proportion of the population; (c) that the working class was becoming more internally differentiated; (d) there was a decline in the traditional central core of the proletariat; (e) that there should be a distinction made between productive and non-productive workers, the latter rising in numbers, and that these could no longer be regarded as part of the working class[7].

Through an analysis of some of the key contemporary debates on the middle class I now proceed to analyse the class position of engineers and systems analysts. The debates that follow from Poulantzas` (1978) categorisation of engineers as part of the `new petit bourgeoisie' to Whalley`s (1986) characterisation of them as `trusted workers' reflect both the conceptual difficulties encountered in locating this strata within the class system and at the same time they enrich our understanding of the issues involved in assigning class positions to specific groups within society.

Engineers and Analysts: The New Petit Bourgeoisie?

One of the earliest and most systematic Marxist reassessments of the class position of `intermediate strata' is the work of Poulantzas. Poulantzas (1978) argues that classes cannot be defined exclusively, at the economic level, stressing the importance of the political and ideological level, in determining social classes. However, it is an essentially economistic analysis that Poulantzas produces[8].

The boundary between Poulantzas` 'new petit bourgeoisie' and the working class is constituted by the distinction between productive and un-productive labour[9]. Poulantzas` definition is:

> Productive labour, in the capitalist mode of production, is labour that produces surplus value whilst directly reproducing the material elements that serve as the substratum of the relations of exploitation (1978: 216).

Yet Marx rejected the criteria of material production, devoting considerable effort to attacking Adam Smith for including this within his definition of productive labour[10]. The concept `productive worker' as used by Marx has absolutely nothing to do with any particular use value produced but is solely about whether the worker produces surplus value. Marx was insistent that:

> the characteristic feature of the capitalist mode of production ... separates the various kinds of labour from each other, therefore also mental and manual labour

> but this in no way alters the relation of each one of these persons to capital being that of wage labourer and in the pre-eminent sense being that of productive labourer (1969: 411).

For Marx, the distinction between productive and unproductive labour is:

> not derived from the material characteristic of labour - neither from the nature of its product, nor from the particular character of labour as concrete labour - but from the definite social form, the social relations of production within which the labour is realised ... the use value of the commodity, in which the labour of a productive worker is embodied, may be of the most futile kind. The material characteristics are, in no way, linked with its nature which on the contrary is only the expression of a definite social relation of production (1969: 157-8).

The narrowness of Poulantzas' definition of productive labour particularly manifests itself when he discusses `service workers'. He contents himself with categorising them as 'unproductive' because their labour is exchanged for revenue. However, as Marx argues:

> From the standpoint of the individual capitalist who invests both labour power and capital in the production of the service, the worker in the service industry is paid from variable capital and not revenue, and the service produced sold as a commodity, irrespective of whether it has a material form or not. As a result surplus value is appropriated by the capitalist (1959: 856).

Wright (1985) argues that no one has ever suggested that the distinction between productive and unproductive capital represents a class boundary between the capitalist class and some other grouping. So why, he argues, should it, between the working class? Wright argues that, typically, the productive/ unproductive capital distinction is treated as one element, defining a fractional boundary *within* the bourgeoisie, such as between banking and industrial capital. However, it could be argued in much the same fashion as Poulantzas argues for the working class, that unproductive capital lies outside the dominant capitalist relations of exploitation and, thus agents occupying the place of unproductive capital should not be considered members of the capitalist class. However, as Wright argues, such a theorisation would be fallacious:

> This argument, of course, would be absurd, because it is obvious that whatever the short run conflicts of interest there might be between productive and unproductive capital, their fundamental class interests are the same. The same can be said for the distinction between productive and unproductive labour (1985: 50).

If the non-productive labourers are not members of the working class, where do they belong? Poulantzas' answer is that they are part of the 'new petit bourgeoisie', which unlike the old petit bourgeoisie, is thrown into being by monopoly capital, rather than being swept away by it. Thus, the 'new petit bourgeoisie' is located within the enlarged state apparatuses and bureaucracies of large companies (as administrators, scientists, engineers, technologists) or distributed amongst the expanding service economy (as clerks, shop workers, MacDonalds workers, etc.). Indeed, all kinds of odd bedfellows are thrown together within this new class, with the result that glaring anomalies and inconsistencies arise. For example, according to Poulantzas' definition, a road sweeper being a non-productive worker (i.e. not directly producing surplus value in the material process of production) should sit in the same class as a corporate manager, doctor or lawyer.

Poulantzas attempts to get out of this dilemma by asserting the importance of political and ideological criteria in the determination of class. Thus, for Poulantzas, an agent who is like a worker at the economic level but deviates on the political or ideological level, is excluded from the proletariat. According to Wright, this:

> Treatment of ideological and political criteria, as effectively coequal with economic criteria stems, at least, in part, from Poulantzas' usage of the notion of the "technical" division of labour ... he incorrectly identifies the technical division of labour, with economic criteria, whenever he discusses the role of political and ideological factors (1985: 51).

In his discussion of engineers and technicians Poulantzas argues:

> We have seen the importance of the mental manual labour division for the supervisory staff and for engineers and technicians. This played a decisive role, in so far as, by way of the primacy of the social division of labour over the technical, it excluded these groupings from the working class, despite the fact that they too perform capitalist productive labour (1978: 251).

Poulantzas is equating the performance of productive labour with the technical division of labour. But if the dominant capitalist relation of exploitation constitutes the essential definition of productive labour it seems unreasonable to treat productive labour as strictly a technical category. Poulantzas roots economic criteria in the technical division of labour and political and ideological criteria in the social division of labour. To the contrary, both should be considered dimensions of the social division of labour. Poulantzas separates engineers from productive manual workers and locates them in a different class because they are supposed to have a different ideological and political determination, i.e. the execution of mental supervisory labour. One engineer I interviewed succinctly captured the improbability of Poulantzas' definition:

> I may be a brain worker but that does not make me middle class, it does not mean I think and act middle class ... anyway, I do as much productive work - design, fixing machinery, organising work teams, etc., as anyone else ... am I less productive than the operator watching over the CNC machine ... it's stupid ... I work shifts ... I get tired, I don't earn enough money, much of my work is routine ... I live in a council flat in Wester Hailles for Christ's sake ... (Electrical Engineer, Post Office, Scotland).

Presumably, a host of ideological criteria could be used to differentiate classes. For example, identifying certain jobs as female and of subordinate status to men's would put men in a position of ideological domination. Yet as Wright argues, `this hardly makes a male worker not a worker!' (1985:53). Poulantzas' use of the term 'new petit bourgeoisie' to denote a new class of agents, not directly engaged in material production and not ideologically subjugated by capital, indicates his unwillingness to break with Marx's three class schema. Yet he is quite aware that both the 'traditional petit bourgeoisie' and the 'new petit bourgeoisie' 'occupy totally dissimilar positions in production' (Poulantzas 1978:37). To resolve this dilemma, he argues that the two groups can be linked because they 'have the same political and ideological characteristics' (ibid: 37). To substantiate this he resorts to schematic labelling, attributing a range of common beliefs, values and attitudes, which he holds both the new and old petit bourgeoisie share:

> These common ideological and political characteristics provide sufficient grounds for considering the two ensembles with different places in the economy as constituting a relatively unified class, the petty bourgeoisie (1978: 38).

We are, thus, back with a descriptive sociology of class that affronts the common sense of those whose position Poulantzas tries to theorise.

Engineers and Analysts: Professional Managerial Class?

Ehrenreich and Ehrenreich (1979) argue that the 'middle class' category of workers which has concerned Marxist analysis for the last two decades must be understood as comprising a distinct class in monopoly capitalist society - the Professional Managerial Class, which:

> Cannot be considered a stratum of a broader class of workers because it exists in an objectively antagonistic relationship to them ... nor can ... be considered a residual class, like the petit bourgeoisie ... (because) ... it is a formation specific to the monopoly stage of capitalism (1979: 9-10).

They argue that this class consists of salaried mental workers who do not own the means of production and whose major function in the social division of labour is the reproduction of capitalist culture - the

> total repertory of solutions and responses to everyday problems and situations and everyday class relations (1979: 12).

In short, the PMC is composed of reproduction specialists. This class emerged in force with the transition to monopoly capitalism and the need to contain rising worker unrest and secure control of work processes (1979). Similarities can be drawn here with Poulantzas' model of the 'new petit bourgeoisie', located in the growing state apparatus and inserted between capital and labour, at the point of production, as agents of control. Like Poulantzas, Ehrenreich and Ehrenreich argue that the PMC is a socially coherent class, with its own culture, values, and shared beliefs (1979). However, Ehrenreich and Ehrenreich do not present a 'managerialist society' thesis, like Bearle and Means (1932), Bell (1973) or Galbraith (1967); but maintain:

> The central dynamic in our society ... lies in the contradiction between the socialised nature of the production process and the private appropriation of production. The interests of the capitalist class remaining fundamentally antagonistic to the interests of wage earners of all kinds, including those we have defined members of the PMC (1979: 42).

Ehrenreich and Ehrenreich present a society in which capital stands in fundamental antagonism to generals, managing directors, the judiciary, senior civil servants and police officers. The PMC as defined seems to me too large and too loosely defined: everyone from a low grade secondary school teacher, technician, doctor to high level executive management is swept into the same class[11].

Engineers are a central concept to Ehrenreich and Ehrenreich, because they are placed in one of the 'more clearly PMC occupations'(1979:31). It is in the work of engineers that the unity of production and reproduction is most clearly seen; and with it, Ehrenreich and Ehrenreichs' folly of defining a class, which includes engineers, merely in terms of a function, called reproduction. To argue that all engineers are 'reproduction specialists' is to ignore the part they play in developing the forces of production and is to assume that all engineers consciously set out to reproduce relations of capitalist domination.

Two concepts critical to Ehrenreich and Ehrenreich are dealt with problematically: class and reproduction. For Ehrenreich and Ehrenreich, the PMC is a class whose function is capitalist reproduction. Ehrenreich and Ehrenreich utilise too narrow a definition of the working class - essentially defining it as productive manual labour. The PMC is divided into two sections, those who carry out their reproductive function explicitly and those who do so implicitly. Ehrenreich and Ehrenreich lump teachers, advertisers, entertainers and media presenters, into the former category and engineers, technologists and lower level middle managers into the latter. Do all teachers really explicitly reproduce capitalist social relations and, likewise, all technologists implicitly reproduce them? Ehrenreich and Ehrenreich foreclose the possibility that some teachers and technologists may be highly critical of capitalist relations and neither explicitly, or implicitly, seek to reproduce them. One analyst I interviewed was adamant that just because he may design systems which secure managerial aims, does not mean he, in turn, either accepts those aims, or sees himself as aligning with a different class:

> Possible consequences of a system I may be working on ... could be to ... let's say lead to an increase in workloads for the girls in accounts ... this does not mean I agree with policy ... like most people, I have my own views ... but you have to repress them in work ... I may design systems which support management in work but I don't necessarily support them at the ballot box (Systems Analyst, Financial Institution, Scotland).

For Ehrenreich and Ehrenreich it is the function of 'reproducing capitalist culture and capitalist relations' (1979: 12) which binds together a relatively disparate bunch of people. Are we to assume that an entire class, as heterogeneous as the PMC, consciously reproduces relations of capitalist domination? For Marx, capital reproduces itself in the process of commodity production and at the same time produces the conditions of its own transformation. Reproduction for Ehrenreich and Ehrenreich stops history. The implication is that the law of value can be overcome and the capitalist system planned. By divorcing reproduction from production they turn historical materialism on its head.

Engineers and Analysts: Contradictory Class Locations?

Wright (1978, 1985) argues that rather than bunching together heterogeneous groups into classes, for the sake of maintaining a three class model of society, why not simply recognise that many positions in the class structure will be ambiguous?

Wright argues that the development of capitalism has generated a number of classes in contradictory locations. In particular, he focuses on three inter-related structural changes: (a) the progressive loss of control over the labour process by direct producers; (b) the progressive differentiation of the functions of capital - emergence of joint stock companies, functionaries without capital and capital without function; and (c) the emergence of complex hierarchies of control on the basis of differentiation of functions.

Wright argues that these hierarchies emerge in conjunction with three components of the basic capital-labour dichotomy: control over the physical means of production, control over labour-power, and control over investment and resource allocation. Under such a schema the proletariat is directly excluded from control over the physical means of production, over the exercise of its labour-power and over investment and resource allocation. Thus, it occupies a definite bi-polar, unambiguous class relation to the bourgeoisie. By contrast, according to Wright, middle managers and technocrats have one foot in the bourgeoisie and one foot in the proletariat, in that they exercise control over others' labour power. The contradictory quality of this class location is evident in the supposed exercise, once again, of a particular set of values and attitudes characteristic of 'professionals'.

It is not true that all workers exercise no control over the physical means of production, their own labour, others' labour, or even investment. Many skilled workers and trades people exercise a large degree of control over their own labour and the tools of labour. More importantly, changes in manufacturing philosophy such as extended quality teams and responsible autonomy strategies, may entail a significant exercise of control by workers over their own work and labour. Likewise, within work teams team leaders, chargehands and a variety of informal works' leaders may be responsible for allocation of tasks, rewards and punishment. Regarding control over investment decisions, whilst senior management may not readily wish the 'books' to be opened, and even less to have workers dictating investment strategies, in certain sectors and in certain countries, it organises their 'participation'[12].

Likewise, to lump together all middle managers and technocrats, *en masse*, into a contradictory class location mid-way between the bourgeoisie and proletariat, is to miss out on the diversity and range of, for example, engineers work, education, training and background. Whilst many engineers may have little, or no control over others' labour or investment decisions, others may be corporate directors, or managers of large production divisions:

> Within this company, you will find a range of engineering practice and degrees of responsibility and control ... a lot of your electrical and mechanical engineers are working on specific 'black box' applications - they are, if you like, technical specialists with little, if any, control over others' labour ... your design and particularly production engineers will have more control, often over large groups of workers and colleagues ... really a lot depends on the particular engineer and type of industry (Chief Design Engineer, Heavy Electrical Engineering Manufacturer, Scotland).

Like Poulantzas, and Ehrenreich and Ehrenreich, Wright locates disparate groups of people in the same class boxes, albeit more of them. Yet to regard a skilled craftsman, a professor in an elite university and the owner of a petrol station franchise, as belonging in the same contradictory class of 'semi-autonomous employees' is to resort to a descriptive schema of class.

Whilst wishing to stress the ways in which historical changes in the development of capitalism have conditioned class structure and, in turn, been conditioned by class, Wright never satisfactorily explains the logic of capitalism. For example, he offers little exploration of the accumulation process and the impact of the ebb and flow of capital into and out of different branches of production in search of above average rates of profit upon skills formation, labour market segmentation, professionalisation and control at work.

The Devaluation Of Engineers And Analysts: The Rise Of The Employee?

One writer who does focus upon the centrality of the accumulation process, in structuring class relations is Carchedi. Carchedi's (1980) main thesis is that a process of devaluation of labour-power is intrinsic to the capitalist mode of production and, historically, this devaluation can be divided into three phases of capitalism:

(1) the initial phase of capitalist industrialisation;

(2) the advent of monopoly capitalism prior to the 2nd World War;

(3) the stage of monopoly capitalism following the 2nd World War and up to the present[13].

Within monopoly capitalism, Carchedi argues, the number of employees increases not only absolutely but, relatively, to the total industrial population. At the same time there is an:

> Acceleration of the process of dequalification of the employees functions; of devaluation of his labour-power, i.e. the knowledge and training necessary to carry out functions which become more and more fragmented, more and more specialised, more and more repetitive in nature (1980: 257).

In this phase, Carchedi argues, the employee finds himself in an increasingly contradictory situation, his condition approaching more and more, that of the proletarian, whilst at the same time he:

> Is asked to stick to an ideology and political practice which is based on a lost position of privilege (1980: 25).

Carchedi sees an increasing deterioration of pay and conditions for many of this 'strata'. For example, private offices are replaced by large work areas and increasing control and surveillance. He also argues, contrary to Poulantzas, that the:

> Only difference between a girl punching cards and a worker on a conveyor belt, is that the former works on a paper conveyor. Any sociological distinction of the type that the former performs intellectual labour, while the latter performs manual labour, is simply absurd. Both meet the requirements needed to be classified within the working class, i.e. neither owns the means of production, both perform the function of the collective worker, are economically oppressed and are paid a wage, the extent of which is determined by the value of their labour power (1980: 258).

Carchedi goes on to argue that in this third phase, employees are increasingly alienated in the work process, losing sense of purposeful activity with the steady de-skilling and routinisation of their work. The growing discontent of this strata can be seen in the attempts to introduce 'job enrichment', 'job enlargement', projects and their increasing readiness to join unions and take part in united front activities with 'blue collar' workers. However, Carchedi argues that none of this is to suggest that proletarianisation necessarily brings about proletarian class consciousness (1980: 259). A number of my interviewees acknowledged these changes:

> I can foresee a time when more and more work will become routine and boring and we will all be either reduced to machine minders, or unemployed ... You only have to scan the computer and systems literature to see that management is trying to secure tighter control over our work ... it's not just the technologies but the division of tasks ... I've seen work become more and more specialised over the years and it's difficult to keep abreast of developments ... there is also far more emphasis on control, within the analysis and design procedure - structured methods, detailed report writing, etc. ... I feel less and less involved in the system design, as a whole, and more alienated from the design ... as we go over to the next generation of user centred languages and packages ... I may even become obsolete (Analyst/Programmer, Financial Institution, Scotland).
>
> I remember when there was a difference between an employee and a worker ... employees were white collar ... workers wore overalls ... now, particularly with these Japanese companies, everyone wants to be an employee ... everyone is called an employee ... but what does it mean? ... Personally, I have witnessed the loss of privileges I used to have - the separate office, the status ... the respect people showed ... we are all open plan here ... we were told it was to break down barriers ... to encourage communication but I think ... (long pause) ... it's all happened with cut backs and job losses and falling differentials ... I've begun to realise that nothing's sacred ... not my job ... no engineer's job ... we are all dispensable ... it's scary really ... (Mechanical Engineer, Engineering Company, Scotland).

In effect, Carchedi draws attention to the contrasting forces operating on 'middle class' employees. Of particular interest here, is his argument that market enhancement of any particular occupational group reflects the extent to which that group serves the 'function of capital'. If an occupation plays an important role in the control and administrative functions of capital, crucial to the production of surplus value, it will command more market power and prestige, which will be reflected in terms of income and status.

However, if a profession has tenuous links with these fundamental capitalist processes, its occupational prestige will be more marginal. This is a provocative analysis which prompted interesting responses from some of my interviewees. Thus one senior accountant working in one of Britain's largest energy producing companies argued:

> As an accountant, I regard myself as a professional ... you only have to look at a cross section of British industry to see the self evident truth that senior management and money crystallise around accounting and finance ... it's probably unfair and, personally, I feel more engineers should be at the helm to give a new direction ... yes, I am aware of the arguments ... I bet that surprised you!! (interviewee smiles knowingly and refers to the arguments of Finneston and "manufacturing excellence") ... on the other hand, why do we get these relatively higher rewards and status. The answer, in my opinion, is because we are in at the very personal and strategic decision making end, where expert knowledge and experience but, above all, professionalism and strength of character matters (Account Manager and Systems Auditor, Private Utility Wales).

Carchedi talks of the rise of the 'collective worker', in the monopoly capitalist phase and an associated process of de-skilling and deterioration of 'employees' leading towards their, presumably, ultimate proletarianisation. Poulantzas, however, draws exactly the reverse conclusions, arguing that it is precisely on the basis of monopoly capitalism that the 'new petit bourgeoisie' derives its existence, as the 'mental' workers of an enlarged state and business apparatus. These workers, unlike Carchedi's 'employees', are not susceptible to proletarianisation but emerge as a strata with skills and capabilities specific to this phase of capitalism - both technical, administrative and control skills; and unlike Carchedi's 'employees', far from feeling a progressive deterioration in their terms and

conditions so moving over to the side of `blue collar' workers, they remain economically, politically and ideologically opposed to them.

The differences between Poulantzas and Carchedi notwithstanding, there are a number of weaknesses in Carchedi's analysis. First, Carchedi theorises the nature of the accumulation process in such a way that he sees capital as systematically dequalifying 'employees'. A more sophisticated analysis would recognise that as capital moves into and out of various branches of production, in search of above average rates of profit, so old skills are destroyed and new ones are created. In effect, skill compositions of workforces are partly contingent on the ebb and flow of capital and cannot be read off from some pathological desire on the part of 'capital', which in any case only exists as many capitals competing in the market place, to de-skill.

Second, and flowing from the above, Carchedi's analysis of why late capitalism should manifest this tendency towards dequalification of the middle class, is unclear. As MacKenzie (1979) argues, cost cutting may be an explanation, or alternatively 'functionaries without capital', may pose a threat to the system so that their proletarianisation, or removal from the scene could then be seen as logical.

Third, Carchedi, following Braverman, presents an omniscient capital, veritably conscious of its own self-interest and systematically and progressively de-skilling 'the middle classes' which passively accept their plight and offer no resistance. This fails to capture the process of change, downplaying the fact that it is Carchedi's 'employees' who are often in the position of formulating policy and interpreting capital's interest and how best to achieve it. As I discovered in my case studies, one only has to listen to the squabbles and clashes of interest between various protagonists (for example, finance managers, marketing and production) to realise that determination of best interest and how to achieve it is far from clear cut but is shaped by the power of respective parties concerned and their ability to drive through, or block, a particular strategy. Carchedi's analysis cannot even begin to tackle such anomalies because his model assumes certain actors to be in either middle class, or in contradictory class positions and pursuing a set of politics appropriate to those positions.

Finally, Carchedi reduces occupational status to whether one carries out the 'function of capital'. This definition, whilst having a gut feel as being right for a number of those I interviewed, nevertheless seems inadequate. Certain occupations with high status and material rewards cannot, automatically, be read off from carrying out the 'function of capital'. For example, Carchedi ignores how the relative high prestige of doctors, university professors, barristers and lawyers, reflects professionals' own attempts to establish status and rewards through monopolisation, self-certification and policing, proscribed and elite routes of entry, and broad and complex ways in which society acknowledges and rewards 'professionalism' (Johnson 1972).

The Degradation of Engineers and Analysts?

Braverman (1974), in his seminal work on deskilling, asserted the primacy of labour process theory within Marxist analysis of class, arguing that the location of class boundaries should be examined in terms of the organisation of the labour process and that class boundaries should be seen as a direct consequence of the accumulation process[14].

Braverman was concerned particularly to show how capital had come to progressively de-skill and proletarianise larger and larger sections of the labour force[15]. However, Braverman's perception of the relationship of the labour process to the accumulation process is unclear. He tends to see the onward march of accumulation leading to a progressive degradation of labour. Resistance to de-skilling on the part of direct producers themselves is downplayed in Braverman's analysis with the consequence that he ignores the fact that accumulation itself is conditioned historically by class struggle and is not an exogenous, pre-determined, process. Braverman also fails to recognise that, as capital moves into and out of various branches of production in search of above average rates of profit, skills will be destroyed and new ones created, e.g. the growth of programmer and analyst skills with the development of information technologies and their increasing centrality to business operations[16].

Braverman, has also been criticised for over emphasising 'de-skilling' as a control strategy. Friedman (1977), Thompson (1984) and other labour process work on managerial strategies, have sought to highlight how a variety of alternative strategies to 'scientific management' are possible for securing the production of surplus-value. Friedman, for example, demonstrates how 'responsible autonomy' is a means of:

> Getting workers to identify with the competitive aims of the enterprise so that they will act responsibly with a minimum of supervision (1977: 48).

Likewise, Edwards (1990) differentiates between several forms of control - direct, technical and bureaucratic. Braverman exaggerates and misinterprets the nature and degree of control it is possible for capital to impose (Child 1984). As Cressey and MacInnes (1980) argue, in doing so he ignores the fact that any tendency towards the real subordination of labour is a process which is `internally contradiction ridden'. If capital is to exploit labour's ability to create surplus value it cannot rely solely on control regimes based around the tight subordination of labour which is implicit in Braverman's analysis; rather, it has to try to harness workers' knowledge, experiences, co-operation and consent. As Burawoy argues:

> The dilemma of capitalist control is to secure surplus value while at the same time keeping it hidden (1985: 32).

He suggests that capital relies on a degree of consent and co-operation in the labour process, without which surplus value producing relations within monopoly capitalism, would break down.

Over-emphasis on control and deskilling is particularly inadequate when it comes to the work of systems analysts and engineers. Many of those I interviewed exercised a high degree of autonomy over their own labour power and argued that far from being de-skilled they were continually learning new skills:

> The pace of change in IT is dramatic ... no sooner have you mastered one language, or technique than another more sophisticated, or elaborate comes along. There is a real shortage of even basic Cobol programmers ... it's crazy but we can't even get enough Cobol programmers ... we are crying out for people with IT skills at all levels (Systems Manager, Automotive Components Manufacture, Wales).
>
> Much of analysis is intuitive and based on sound business understanding, interpersonal and communication skills ... you can't replicate this in a bit of expert software ... only when you can get a machine to go out and talk to users, at a variety of different levels and for it to be able to apply all the means of persuasion and flattery that is needed, will you get anywhere near automating, or deskilling the work of analysts. Analysts are professionals ... you need to allow a degree of self-administration and freedom for creativity ... otherwise you will not get the best out of people (Systems Analyst, Major Public Utility, Wales).

Whilst recognising that `professionals' need space and freedom for creativity, engineers and analysts seem to fall short of recognising that their own work process may also be rationalised in the name of efficiency (Greenbaum 1976, Kraft 1979). As Jamous and Peloille (1970) argue, this is a classic response of professionals working in areas where a high degree of indeterminacy exists, that is, where tasks are variable and non-rationalised, the people who control this uncertainty being likely to enjoy high status and to combat any attempt to routinise work in terms of infringement or compromisation of professionalism.

Whilst one might expect a tendency towards de-skilling within capitalism, Braverman, nonetheless, offers too deterministic a process of labour degradation, presenting an image of an omnipotent capital capable of automatically mustering the strategies and technologies necessary to de-skill. Such analysis downplays agency on the part of designers and managers and assumes that both capital and designers share a common understanding of the task in hand and dutifully proceed to develop strategies and technologies accordingly. My research indicates that this is hardly a realistic scenario. Many designers, even managers, do not automatically accept, or understand the logic of 'capital interest', or the need for labour degradation. Indeed, they may actually oppose this logic on purely personal, 'irrational' grounds:

> We had spent several million pounds integrating our existing information systems, in an attempt to standardised hardware and software throughout the bank ... it has been an ongoing process ... involving a number of sweeping technical and organisational changes ... there has been a lot of risks and negotiation ... for several months corporate management were made aware ... by myself and others of a number of system discrepancies.....we were finding decimal points in the wrong places ... thousands of pounds out ... withdrawals and entries in accounts that did not make sense ... I was under a lot of pressure ... at first, we thought it was technical error ... eventually we found the sources ... a senior manager in one department was intentionally tripping the system ... why, because restructuring had meant the loss of some of his staff and in particular a number of secretaries - who will remain nameless ... his behaviour

> was totally irrational and unprofessional ... it cost the bank dearly ... you've got to admire the guy for having the balls ... I mean, as a person I know him well ... we've played a few rounds of golf, etc. ... but it's not the kind of thing we wanted public, so this manager was asked to resign quietly! (IT Director, Major High Street Bank).

The IT director lambastes a senior manager for `irrationally' opposing and, indeed, sabotaging, the new IT system stating, that such behaviour was `unprofessional'. Yet he, nonetheless, relayed the above episode to me with some degree of admiration and even sympathy for the man who made his life difficult for so long. Braverman's analysis fails to capture the dialectic of control and resistance in the work of the very 'strata' whom, he asserts both assume 'capital's logic' or 'principles' and systematically seek to impose them on others. Within monopoly capitalism, decisions over investment and strategy are made and influenced by a variety of actors within the 'collective labourer' and as the above account demonstrates, even within senior management, there may be a plurality of interest groups and individuals entering into discourse and pulling in different and, often, contradictory, directions.

Engineers and Analysts: Trusted Workers or Distrusted Professionals?

Whalley (1986) finds little evidence of a trend towards the de-skilling of engineers, arguing that unlike craft workers, engineers do not control access to a specialised body of knowledge, so the need to de-skill them is absent. They do, however, according to

Whalley, occupy a distinctive place in the division of labour based on trust; the nature of that place, access to it, and even the qualifications required for it, however, are controlled by management.

It hardly seems reasonable to argue that engineers do not possess specialised knowledge. The engineers I interviewed certainly believed they did, as did managers within the same companies:

> I've spent several years at university getting the necessary qualifications for my job and this does not count the large number of specialist courses I have attended, for example, in software engineering ... if this is not specialist knowledge, what is it? (Electrical Engineer, Heavy Electrical Engineering Company, Scotland).
>
> Our engineers are highly trained people ... in fact, they have become more so as the years have gone by ... probably what confuses people is that they have become more specialised and less general ... to keep abreast of the technology, you have to continually update your learning - I fail to see how you can argue that this is not specialised knowledge ... it is surely this that we pay for (Chief Design Engineer, Heavy Electrical Engineering Company, Scotland).

My research indicates that engineers and analysts *do* possess specialised knowledge and partly because of this are a much more difficult strata to control than Whalley suggests. If the need to de-skill is absent, why are so many trade journals like 'Case Strategies' (1989) full of products, technologies, methodologies and strategies for controlling and, indeed, automating parts of the analysis, design and developmental processes of computer software? Maybe managers would like to deskill engineers' and analysts' work but find, for a variety of reasons, that it is not easy or worthwhile to do so. A number of managers I interviewed acknowledged this to be the case:

> The principle means (of exercising control and de-skilling) is through the division of labour and the project team ... tasks are allocated to specific individuals and they have to report back through the project managers to me. Obviously, you do not always know in advance how long a particular task will take, for example, information gathering, or sorting out bugs in a program ... To a large extent, you are reliant on the skills and initiative of your staff ... but there are tools and techniques available to managers to enable them to monitor labour productivity and quality of programmers and analysts - for example, we have software which can monitor the number of lines of error free code written, we have structured methodologies which lay out standard systems analysis and design procedures ... there are also other tools available - software that can monitor systems analyst productivity, clocking on and off and even qualitative appraisal of designs ... but it's all very embryo and easily by-passed ... to be honest, it would probably be counter productive to impose too rigid a control structure in this line of creative work ... analysts need the status to converse with users and need the self respect being a professional brings ... anyway, they could always retort that they work at home, or that they want charging for the time that they think ... or alternatively, they can just get up and leave secure in the knowledge they can walk straight into another job (Systems Manager, US Electronics Company, Wales).

Whalley's concept of engineers as 'trusted workers' fails to acknowledge that capital relies on the trust of a variety of sections of the labour force, even unskilled operatives, otherwise, the production of surplus-value would rely solely upon coercion and expensive and, ultimately, counter-productive means of rules punishment[17].

Whereas for Whalley engineers are 'trusted workers', Armstrong (1989) argues exactly the reverse: that is, engineers are held in subordinate positions in the lower middle class by a senior management which, Armstrong argues, is fearful and distrusting of engineers 'productivist' knowledge and culture[18].

Armstrong perceives management as part of unproductive labour, not being surplus value producing labour carrying out functions of control and co-ordination. However, I found that many engineers carry out highly discretionary tasks, often exercising large degrees of control over others' labour, along with a large degree of co-ordination of labour processes:

> It is complete balderdash to claim engineers only carry out technical, or productive tasks ... it depends upon which engineers you are referring to. I manage this entire factory, hire and fire labour, organise work, meet suppliers, do orders and do design ... all my engineers have high degrees of managerial responsibility for the work of others ... I'm fed up with all this bleeding heart stuff about engineers being mere technicians ... in reality, we are managers with technical skills (Managing Director and Senior Production Engineer, Medium-sized Chemical Company, Scotland).
>
> The whole purpose behind graduate entry and the inclusion of managerial and business syllabi into the engineering curriculum is to provide sound managerial skills for engineers ... I agree that in Britain, engineers tend not to make it to the top ... but in Japan, France, Germany, or the USA they do ... so it's a peculiarly British thing ... but I think things will change as curriculum improve and the latest graduates feed through the system (Professor and Director, Artificial Intelligence Centre, Scotland).

Armstrong's (1989) reduction of engineers to subordinate elements of the middle class, by dint of their possession of 'productivist' knowledge and their perceived unfitness for senior managerial positions by a managerial elite steeped in a 'gin and tonic' culture of finance and short term profitability, has appeal; for example, this interpretation formed the backbone of the Finneston Report. However, Armstrong fails to recognise the diversity of engineering jobs and, consequently, the diversity of engineers' responsibilities and exercise of co-ordination of others' labour. Likewise, he offers a one-dimensional analysis of class which is presented along a productivist/non-productivist axis, with the consequence that there is no relational understanding of class, for example, engineers changing relationship to shop floor workers, or the owners of capital (Smith 1986).

Engineers and Analysts as Collective Labourers

Most engineers and analysts I studied are part of the 'collective labourer' (Marx 1959: 508) but they are not, generally, subordinate elements of that collective labour. Indeed, some are not, accurately speaking, part of the 'collective labourer' at all, in that they occupy ownership positions within their companies, or are self-employed working contracts, or running their own consultancies; yet others may have dual roles - doing their own fee paid consultancy work whilst also being employees within a larger organisation.

The nature of most engineers' and analysts' work - the tools, techniques and methodologies they deploy, along with their specific position within the division of labour as repositories of knowledge and skills won from craft labour - ensures that bourgeois class interests broadly defined become concretised within the design process. This is not to argue, however, that the majority of engineers, or analysts, are 'agents' of the bourgeoisie, or part of a 'new middle class'. The term middle class is too vague and too imprecise to capture the reality of their work and their broader social existence. The group is too diverse and too heterogeneous both in terms of types of work undertaken, positions held, social background, education, training and routes of entry. More importantly, both engineers and analysts are prey to the vagaries of the market, the cycle of accumulation and the rationalisation and cost cutting exercises that other sellers of labour-power experience.

Class theorists have paid insufficient attention to the differential impact of the accumulation process on different sections of the 'collective labourer' - that is, on the formation and transformation of classes and class consciousness. This is particularly alarming, given the nature and breadth of contemporary changes in manufacturing. For example, recent changes in the job remits, demarcations, tasks and status levels of managerial and technical workers, as a consequence of work reorganisations around information technology and, in particular, around JIT, CIM, CAD/CAM and robotics (Ribbens 1989, Swords-Isherwood 1980, Rajan 1985, Senker & Beasley 1986, Goodridge 1991). Not only are traditional job boundaries becoming blurred, as many employees and managers redefine their skills and status, but the physical composition of the workforce is changing dramatically, both in terms of a shift towards services, credentialism and a dramatic increase in female and part-time employment (AAS 1993, Employment Gazette 1994).

New organisational cultures and particularly the emphasis in a number of companies I studied on `harmonised' non-conflictual work relations, are having an impact on the class consciousness of employees at a variety of levels. One personnel manager who was directly involved in the creation of single status `harmonised' policy in her company had the following observation:

> We abolished formal status differences within the company and went for a single union flexible package with the EETPU ... the workforce love it ... we have improved facilities, single status canteen, parking, toilets and services, everyone here is salaried ... it's good because it abolishes snobbery and status differences between the workforce and managers ... we share a unity of purpose a common interest for the company (Personnel Manager, Japanese Electronics and Software Manufacturer, Mid-Wales).

I asked if having single status and `harmonised' work relations applied to everyone and what impact it had on employee consciousness:

> We chose this greenfield site because we wanted to start afresh with no history of conflict, unions, or demarcation, etc. ... all management and core workers are on salaried status ... and in our profit sharing scheme ... out intention is to abolish overt status differences and opt for a new kind of industrial relations based upon harmony, shared responsibility and oneness ... some managers have found this difficult, they feel their authority should be recognised ... they will either have to change their mind or leave ... our objective is to have conflict-free industrial relations ... through eliminating the most obvious signs of class and status difference within the company ... we are well on our way to achieving this ... I

> doubt the majority of the workforce are even aware of class at all (Personnel Manager, Japanese Electronics Manufacturer, Mid-Wales).

The argument here is that class consciousness will be suffocated under an ideology of co-operation and harmony, suitably reinforced by the removal of the most obvious signs of status and class and buttressed by employee profit sharing schemes. That a significant number of companies are going down this path and taking advantage of favourable labour market and legislative conditions to try and engineer this new culture, indicates the seriousness with which they treat the issue of class.

As capital ebbs and flows into and out of various branches of production in search of above average rates of profit, so new businesses are opened up and less profitable ones rationalised, or closed down. Information technology is at the cutting edge, not only in the sense that it is a new and expanding industry, in its own right, but also that information technology and information technologists are becoming increasingly key to the restructuring and rationalisation of other businesses. Resources within companies are being channelled into information technology as it becomes a more central part of their operations. This not only puts key IT staff in strong bargaining positions, *vis a vis* salaries, terms and conditions, but generates an air of optimism and vitality which informs systems analysts' perceptions of their status and class.

A startling contrast emerged in my research between engineers' and systems analysts' perceptions of self-worth and status and the way these fed into their conceptualisation of class. Analysts were generally perceived by both engineers and systems analysts as riding the crest of a technological wave and drawing their status and esteem from this:

> Many in this industry think the bubble wont burst. That they are technological front runners who will always be in demand and will always be able to get what they want...and maybe they will...but it certainly affects their attitude to users generally and I would suggest their politics in particular....it can make them elitist...well maybe that's a bit harsh...but certainly many are your archetypal yuppies and stupidly cultivate this image both in dress, style and manner.... (Systems Manager, Large Financial Institution, Scotland)

In effect, analysts are the social group implementing the rationalising technologies that capital requires to secure profitability in the 1990s and they feel confident about their centrality to business and the development of their own careers. Analyst status is, however, not derivative of the fact that they are carrying out the global interests of capital, as defined by Carchedi (1980), but rather, that they are taking advantage of severe skills shortfalls in the area of IT and because of management's general lack of awareness of IT and its capabilities:

> If you are young, free and single and in this business, you are riding a technological tidal wave ... there is big money to be made ... now I prefer a steadier pace ... but even here the money is good, the job carries a lot of respect ... you can really develop yourself ... I suppose in one sense, I feel guilty because whilst I've been progressing and getting richer, I know millions have been experiencing the very reverse ... when I was a bit younger and more politically naive, I let things go to my head and I'm sorry to say, I voted Thatcher ...

> because I genuinely believed she was a moderniser ... I was wrong but I know plenty of other analysts who went down the same path and still believe they are right (Senior Systems Analyst, Large Financial House, Scotland).

Engineers, by contrast, are less riding a technological tidal wave as left wallowing in a sea of business closures and rationalisations. This has profound implications for the way engineers and analysts perceive themselves:

> Engineering is not what it used to be ... I don't think we ever had the status we deserved but things are worse now ... industry is collapsing, projects are declining ... many of the skills are not required ... the steel industry, coal, manufacturing generally are all in recession ... I've seen my pay fall relatively over the years and conditions both here and elsewhere deteriorate ... it creates a situation of apathy and betrayal ... really, I don't think the majority of us are middle class any more ... where did it get us anyway ... we should have pursued a more rigorous policy in relation to pay and professionalisation ... the way I see it, it's no wonder many engineers are turning militant, or simply wanting to get out of the industry, it's dead end (Electrical Engineer, Large Electronics Defence Contractor, Scotland).

By contrast one systems analyst commented:

> Many in this industry are perceived as yuppies. Young, professional, lots of money, flashy cars and lifestyle and no values ... it's sad but a lot are like this ... particularly, some of the younger ones, but this is part of the grab-it-while-you-can culture we live in ... we're not all like this though ... I recognise that we are in an advantageous position compared to engineers generally ... because we have the skills and expertise that the market demands ... and obviously this must influence your politics and attitudes ... but I try not to let it go to my head (Systems Analyst, Large Public Utility, Wales).

This image of the analyst as technological front runner, and engineer as part of a dying breed, was one which recurred. It is manifest not only in individuals' perceptions of the two professions but in the material world in which they both work. Invariably analysts would dress in smart suits, work in plusher, better decorated, brighter, airier and more well equipped offices, whilst engineers tended to be less fashion conscious, and work in shoddier, gloomier environments. This is explained in part by the fact that many analysts are at the managerial, business driven end of design. IT is also seen as newer, cleaner and more strategic; hence IT staff, generally, had better conditions and a glossier image than engineers, even though in terms of qualifications and training they fared worse.

According to Edgell (1993) one of the problems of defining adequately engineers' and analysts' class position is choosing which operational model of class to use - occupation, income, cultural or political traits, property possession, education or whatever. As I have argued, this approach to class tends to define classes in terms of inbuilt properties, rather than seeing class as a relational entity.

Ironically, engineers and analysts utilise the occupational and income model of class most frequently in trying to define their class position. Yet sensing the inadequacy of this model alone then seek to bring into the picture, broader conceptions of social class:

> Ostensibly, I would say I am middle class because I am a professional - both in terms of my job and income, this is how I am classed for census purposes ... certainly, it's what my wife thinks ... but it's not this simple ... I don't vote Liberal Democrat or Conservative ... I was born in Govan ... I prefer going to a match,

> rather than the theatre ... I'd rather have a pint with the lads than go to a restaurant ... and I've voted labour all my life just like my father (Mechanical Engineer, Power Generating Company, Scotland).
>
> I would see myself as middle class ... but not your typical middle class type ... I suppose many would see me as a yuppie ... I get ribbed about this by my old pals ... they point to the salary and flashy car and think I'm different to them ... more successful ... I suppose I am, in many ways in that I've got a good professional job with good career and earning prospects ... but I'm not your cultivated type ... I suppose I'm still working class in many ways ... after all, I still have to work for a living and still get tired and pressured at work (Systems Analyst, US Electronics Company, Scotland).
>
> As a professional, I would regard myself as middle class ... my job, my income ... the university background point to this ... so er ... (stops to pause for a while) ... er ... but I'm not quite happy with this definition ... it doesn't seem quite right ... really it's pretty arbitrary ... I come from a working class family, my children have just started at the local comprehensive ... what can I say ... I suppose the further you climb the systems ladder, the more middle class you might become ... no, that can't be true, look at John (the systems manager) he's an animal ... more working class than a worker ... (Systems Analyst, Automotive Components Manufacturer, Wales).

Goldthorpe (1972) highlighted how the growth in post war administrative and managerial posts widened the recruiting base of the middle class, to include substantial numbers of working class, who did not possess the cultural capital of the traditional professional managerial class and helped dilute it. The rapid growth in engineering in the 1960s and 1970s and the even more dramatic growth of information technology, throughout the 1980s and 1990s, has stimulated demand for skilled labour, much of which is recruited from working class families. This is particularly so for systems analysts and IT professionals generally (University Statistical Records 1994). Samuel (1982) has painted an evocative portrait of the cultural capital of this new professional strata which:

> Distinguishes itself more by its spending than by its saving. The Sunday colour supplements give it both a fantasy life and a set of cultural cues. Much of its claim to culture rests on the conspicuous display of good taste, whether in the form of kitchen ware, continental food, or weekend sailing and cottages ... Class hardly enters into the new middle class conception of themselves. Many of them work in an institutional world of find gradations but no clear lines of antagonism.
> The new middle class have a different emotional economy to that of their pre-war predecessors ... making a positive virtue of their expenditure, and treating the self-indulgent as an ostentatious display of good taste (New Society, April 1982).

For Samuel, this strata is seen as a distinct class - the new middle class - whereas my own research indicates that groups comprising this strata, are, generally, better conceptualised in terms of non-subordinate elements of the `collective labourer'. This model has the advantage that one can still discuss possible cultural capitals that different members of the collective labourer may possess whilst at the same time not having to reduce those capitals to specific class practices and pre-fixed class positions. Thus, whilst some of my interviewees displayed the traits noted by Samuel, others did not, and, importantly, were deeply offended by such caricatures:

> On the one hand, there is this emphasis on lifestyles which took off in the early eighties ... key professionals, it seems to me, were targeted in adverts not only on television, but in the trade journals ... particularly IT journals ... so there's this image and expectation we have and others have about how we should act, what our tastes and politics are, or should be ... well it's all bullshit ... just image building and to be honest many of us find it offensive, particularly the older ones ... it's not only damaging vis a vis your relations with users ... but it's tiring being the butt of countless Yuppie jokes ... (Senior Systems Analyst, Large Financial Institution, Scotland).

Indeed, the new political realism fuelled in the eighties by the collapse of East European economies and the apparent bankruptcy of socialist politics provided fertile terrain upon which the seeds of populism and despair took root as a new cultural nihilism expressed in the 'me now culture', was given open legitimacy and reinforced by a revival of monetarist and free market policies. Many engineers` and systems analysts` conceptions of class, like those of other sections of the collective labourer, are interwoven within this new socio/political milieu. What is surprising, given this backdrop, is that many engineers and analysts so openly recognise the saliency of class. A significant number I interviewed argued that they come from working class backgrounds. Indeed, contrary to Samuel's presentation, some make great play on this, using it to establish their credibility and suitability for the job they were in:

> I'm not wet behind the ears like some college-nosed graduate ... I can't be ridiculed and have the piss taken out of me so easily by the lads on the shop floor ... because I've been there, I know how they think that what motivates them (Systems Analyst, US Electronics Company, Scotland).
>
> This job requires basic common sense and strength of character some may see my background as a disqualification for this job ... but I think coming from a working class background enables me to do the job better, it gives me more insights (Systems Analyst, Large Private Utility, Wales).

In many instances, engineers and analysts would utilise notions of 'common sense', 'nouse' or 'strength of character', to identify what were seen as noble characteristics of working class life which they admired and wanted to be associated with. Murray (1989) makes a similar point in his study of systems staff, citing one manager, in particular, who made the analogy with miners, leanness and absence of excess weight:

> I liken us to coal workers. We dig coal. We deliver things that are tangible to our users ... we are lean, very lean. We've got no fat on us (Project Manager cited Murray 1989: 7).

A few analysts and engineers went so far as to argue that not only was their work in many ways analogous to that of production workers producing tangible artefacts but that they were, in fact, working class.

> I work for a salary ... I have to get up Monday morning and go to work ... whether I like to, or not ... work can be tiring and pressured and it has been recently, what with the pressure to meets demands for deadlines ... no really I know many people would see me as middle class ... but they are the same silly lads and lasses who see typists, junior office clerks and hairdressers as middle class (Systems Analyst, Regional Power Generating Utility, Wales).

One engineer, in particular, pointed to the detailed division, of labour, rise of specialist knowledge and lack of innovative and interesting work, to highlight why he felt he, as engineers more generally, were working class:

> You need to remember that engineering is becoming more specialised, certain skills are in demand like CAD engineers ... but it's not like it used to be ... your rounded engineer, with broad-based skills, is simply not required, employers want specialist knowledge and they bring you in to do that one task ... then you are out ... there is also a lack of work ... and what work there is available is becoming more routine and boring ... I don't get a buzz out of this job, or feel I'm anything special ... I'm struggling to pay the mortgage and moving from one

short term contract to another ... it's very insecure ... I feel like a worker and in my opinion am treated like a worker (Electronic Engineer, Large Public Service Institution, Scotland).

Smith (1986) and Whalley (1987) agree that shifts towards graduate recruitment, within engineering, following the ending of the old seven year craft apprenticeship, have weakened ties between engineers and shop floor workers. My own research confirms that many engineering and systems managers feel that graduate recruitment is having an impact on the class composition of engineers and analysts and giving rise to different forms of conduct and behaviour:

My college graduates are bright boys, don't get me wrong but there is something not quite the same about their relationship to the shop floor that there was in the craft apprenticed engineer ... it is a vital element lost, in many firms ... it's not even a question of communication ... it's more than that, it's tacit knowledge, respect for, and joint appreciation of each other's tasks ... some graduates in some firms never go near the shop floor they remain aloof ... I won't tolerate that here (Chief Engineer, Aerospace Industry, England).

With graduate intake, the image of professionalism has grown ... it's a good thing in one sense but something has been lost in the process. We need graduates and their specialist knowledge, don't get me wrong ... but they are often out of touch with workers in production ... engineering is about getting things made and this requires co-operation ... some of our graduates get up people's backs ... arrogant is a word that comes to mind ... they just want to delegate everything and not get their hands dirty. I cannot see these people having much in common with those on the shop floor. We've had a few, who on realising this, have upped and off (Chief Design Engineer, Heavy Electrical Equipment Manufacturer, Scotland).

One systems manager was forthright in his condemnation of graduates:

> I'll be frank with you, I don't want bloody graduates in my department, they are more trouble than they are worth ... systems design requires sensitivity and good communication skills and an appreciation of others' positions ... but too many graduates don't possess any of these qualities, they tend to be snotty and elitist ... part of a different class ... this makes them abrasive with users (Systems Manager, Food and Drink Processing Industry, Scotland).

Not all systems managers were of this ilk. Indeed, most recognised the need for professionalisation and credentialism within the computer industry and that graduate recruitment was a way of achieving this. Ironically, graduates because they are perceived to be of a different class, can be seen as possible sources of tension and conflict within the design process at the same time as being a necessary part of analysts' and engineers' attempts to advance professionalisation.

However, not all graduates take an elitist view of design or shop floor workers and feel that it is either managers, or shop floor workers themselves, who cause the tension:

> I graduated four years ago ... since then I have had two jobs, both in electronics ... I sense the tension sometimes between colleagues and workers in production and myself ... I think they think I am a bit snotty because I came out of university with a good degree ... it can get tiresome ... particularly when your own boss is reminding you continuously about good commonsensical values and intuitive design ... (Systems Analyst, Food and Drink Processing Industry, Scotland).
>
> Just because I come from a solidly middle class background and went to university, doesn't mean I am anti-trade unionist and pro-Thatcher ... I actually belong in the MSF which is one of four unions organising technical and managerial staffs here. I am also a Member of the Institute of Electrical and Electronic Engineers, out of a desire to keep abreast of technological developments and to advance the profession ... politically none of the parties interest me ... they are all out to screw the working man (Electrical and Electronics Engineer, Japanese Domestic Appliance Manufacturer, Wales).

This engineer was keen to highlight that his membership of both the MSF and the IEE represented something of a contradictory position in the sense that it recognised that engineers' position is deteriorating, both in terms of pay and professional recognition. He was adamant that there was no contradiction between professionalism and unionism, rather:

> I, like all workers, need to maintain and improve my living standards ... many older and more senior engineers are aloof from this reality, that's why we are in such a bloody awful position with respect to other occupations ... at the same time, just because I want to see engineering have more recognition doesn't mean I see engineering in elitist terms ... rather without the professional recognition it's more difficult to bargain with employers ... who tend to treat you like shit anyway (Electrical and Electronic Engineer, ibid).

Interestingly, he argued that one reason why he joined the MSF was that he believed it would take a more militant stand in advancing engineers pay and status within the company. Smith (1986) highlights how TASS, which later merged with ASTMS to form the MSF, dropped its militant industrial unionism of the seventies to accommodate the separatist and elitist views of graduate engineers. Smith's argument is that elitism, whilst endemic to engineers' place in the division of labour, can also exist alongside values of co-operation and unity; much depends on the political organisation of the union and the development of class relations within the workplace. Cooley (1980) makes a similar point when he demonstrates how in the Lucas Aerospace Combine

Committee many engineers were won over to the side of striking shop floor workers in a united front against closures and redundancy.

Whilst engineers and analysts often design systems that de-skill, downgrade and routinise workers' lives, this does not make all engineers, or analysts either willing agents of the bourgeoisie, or as a consequence, petit-bourgeoisie themselves. Many workers intensify the exploitation of their fellow workers, be it within the competitive confines of quality teams, informal team leaders, union discrimination against female, part-time and un-skilled workers, utilisation of job demarcations and restrictive practices against other workers, or agreement to productivity and quality related bonus schemes, won at other workers' expense. In addition, many workers carry out supervisory functions - chargehands, foremen, setters, team leaders, or in informal work teams where individuals and groups emerge who seek to impose work and productivity norms. This does not mean they are not part of the collective labourer, although it does indicate that they lack consciousness of their own role in subordinating workers' interests to capital - that is, they lack class consciousness.

Most engineers and analysts I interviewed are part of the collective labourer but by and large they are not class conscious labourers. They tend to design systems which secure bourgeois class interests within the design process. However, these designs are not theorised in terms of securing a particular class interest but in terms of securing 'system interests' and 'efficiency' broadly defined. In effect, the tools, techniques, values and methods that engineers and analysts use, reinforce bourgeois class interest by presenting these interests in technical, rational and systemic forms. Thus, control and systems theory, cost benefit analysis, technicist and business rationality, and even notions of design purity can act together to constitute a design milieu which is both uncritical of existing power structures and design approaches, whilst, at the same time, legitimising the design approaches taken on the grounds that they are rational and the most efficient:

> It is imperative within any design not to jeopardise the functionality of the system ... (Systems Analyst, Power Generating Utility, Wales).
>
> Sometimes you have to make decisions on job allocation and possible demarcation, or skilling, as a consequence of your design ... nobody wants to put people out of work, or see them lose pay ... but you can't sacrifice efficiency ... for the sake of personal preference (Production Engineer, Pharmaceutical Manufacturer, Scotland).

Habermas (1973) and Murray (1989) have highlighted the ways in which technical rationality can serve to mask specific class based decisions within the design process, behind an apparent value free notion of the organisation as a machine-like entity within which individuals are

> Only cogs in an ever-moving mechanism which prescribes them an essentially fixed route of march (Weber cited Giddens 1972: 47).

It would be easy to dismiss engineers' and analysts' presentation of their work and design in this way as simple apology on their part. To do so, however, would be to downplay the way in which particular tools, techniques and approaches come to embody deeper value systems and act to structure often, unconsciously, designers' work. One engineer I interviewed was exceptional in that he openly professed that many of the tools and techniques analysts use are value loaded:

> Cost benefit analysis is used to justify managerial decisions ... you can use it to prove any design you want ... structured methods, imposed on analysts by many managers and consultants, emphasise getting the requirements right - management requirements - they do not encourage you to challenge the boundaries of a system ... Structured methods also act as a management control tool ... CASE and all the other software engineering tools are just that - tools ... but their architecture and structure, the context of their use - the whole division of labour and control of projects through project management software and practices - is geared towards ensuring management's interests predominate within the design process ... and presenting these interests as rational and inevitable ... but I suggest most systems analysts would recoil in horror at this suggestion (Software Engineer, University, Scotland).

The same engineer highlighted how systems analysis and design takes place through institutionalised divisions of labour - project teams and often close senior user liaison which in turn acts to cushion the analyst from the consequences of their designs on others' lives - for example, leaving issues of job relocation, regrading or losses to personnel or senior user managers.

However, even despite the array of tools and techniques and the specific divisions of labour within design, which tend to cushion analysts and engineers from the broader ramifications of their work, a small number of those I interviewed were visibly troubled by the consequences of their designs on other workers. They did not like to discuss the issue - they invariably presented their designs in technical - rational terms first, but the strength of this ideology was not always enough to hide the decisions taken and the political and social consequences which flowed from them:

> Of course it bothers me, knowing I may be putting someone out of a job, or reducing their pay packet, as a consequence of my action ... it's painful ... We're only human ... many of these people you've known possibly for years ... like you they have a wife and kids and mortgage ... and you know ... at the back of your mind that it's you who has wrecked their lives (Systems Analyst, Large Private Utility, Wales).
>
> Sure, I've had sleepless nights and nightmares about my work ... I try and rationalise what I do in terms of long term efficiency and job savings ... but watching some poor sod leave the gate on Friday afternoon after years of service ... knowing you've put him there ... can cut right into you ... oh yes, it hurts (Industrial Engineer, Chemical Company, Scotland).

The fact that systems design is political after all and that analysts and designers make political decisions is too much for some to bear. According to one systems manager:

> These types are better offered technical careers ... you can utilise their technical knowledge and reward them accordingly and leave the more up front work to those who are less troubled by making these decisions (Systems Manager, Automotive Components Manufacturer, Wales).

However, it is not this easy because as more complex interactive systems come on line, IS staff generally are opened up to the political decision making process. Ironically, as Murray (1989) argues, many do not want this. Rather they wish to be 'strapped to the user' and to let the user managers make the painful decisions on system requirements, etc. and just let the IS staff build the system. However, at the same time, they recognise that users are not always in the best position to define these requirements, that in effect user requirements might not meet systems requirements. Murray cites the case of one particular project manager, Mike, to highlight the point:

> It is a strange autonomy, Mike lays claim to for, on the one hand, he appears to want to be dictated to, while, on the other, he wants to be able to say to senior management, "this is what you can have". And, while being "totally tied" to the business, he rather seems to want to run the systems development show all by himself (Murray 1989: 11).

Murray argues that many analysts and IT managers appear to articulate a service/servile mentality:

> What they appear to want is someone who will tell them clearly what to do, who will subjugate them, and who will ensure they are totally tied to the business. This desire to be enslaved by, and hooked to, the business conjures up images of bondage and martyrdom Prometheus chained to the rock (1989: 12).

Obviously not all engineers and analysts I interviewed displayed concern over the impact of their design on workers' lives. A tiny minority expressed overtly anti-workerist sentiment. These were invariably consultant, or senior managers themselves - i.e. directors and significant shareholders in the companies they worked; only a few could be regarded as part of the collective labourer:

> Workers are there to work and management to manage, it's not my job to improve the quality of workers' lives ... my task is to give management the power it needs to manager (Senior IT Consultant, Major UK Consultancy).

More often than not, it was not so much that analysts, or engineers were anti-workerist. Rather, they tended to perceive the human operator as an area of ambiguity and possible system dysfunction, and consequently the source of potentially extra work and stress:

> I'm not against trade unions ... I recognise they do a vital job ... I'm in one myself ... but they can make life difficult when it comes to design (Systems Analyst, Financial Institution, Scotland).
>
> I don't think any of my lads have bad feelings towards users at whatever level ... it's not bad feeling, more like ... sometimes you just wish you were dealing with the technology ... it's less troublesome (Chief Engineer, Pharmaceutical Industry, Scotland).

Marx (1959) analysed the various strata within the collective labourer by utilising the concept of subordination. A factory worker would be seen as carrying out subordinate functions, a manager non-subordinate functions. Which strata within the collective labourer carry out which functions is contingent on class struggle and the ever changing cycle of accumulation which acts to condition the particular social division of labour, at any point in time. In effect, what constitutes a dominant and subordinate section of the collective labourer at any one particular historical conjuncture, may not do so at another. For the sake of descriptive elegance, an entire school of sociologists define class in terms of inbuilt frozen fast parameters. However, struggle within the labour process over skills, pay and conditions, is an ongoing process intimately bound up with the cycle of accumulation and the appropriation of surplus-value. It is a process involving a variety of different actors, organisations, interest groups and ideologies which are different, in different places and times. By defining class in terms of fixed attributes like skill, politics, or ideology, or along arbitrary productive non-productive axis, one runs the risk (as many on the left have done) of ignoring key social groups, or consigning other groups within the collective labourer into different camps, in terms of whether they are more or less ideologically sound.

Marx's theorisation of 'collective labourer', recognises the domination of the mode of extraction of surplus value in determining the relations of rulers and ruled, whilst at the same time, recognising that these social relations, nonetheless, in turn impact back upon the mode of surplus-value extraction. Capitalist production, creating a mass of workers who are compelled into union to defend common interests but who at the same time are split in a myriad of ways - skills, pay, sexism, nationalism political persuasion, etc. (Marx 1972). One can be a racist bigot, union hater and sexist but still be part of the collective labourer - the collective labourer is not a class or homogenous mass with uniform consciousness. Indeed, Marx utilised the concept precisely to accommodate the myriad fracturing of working class consciousness, as the capitalist division of labour and commodification of more and more sections of social life occurred. The key point is, that within the collective labourer, different groups will have different levels of political consciousness. That is, they will conceptualise their relationship to other groups differently and this consciousness may transform as relations between its bearers change over time. For example, blue collar male manual workers may at one time have constituted the core working class, standing in a particular articulation to management, organised around particular productive technique and articulating specific values and ideologies, for example, concerning the organisation and control of production. At another time it may be white bloused females, or high tech cerebral workers, who are standing in a new articulation to a differently constituted management.

The development and transformation of strata within the 'collective labourer' is intimately bound up with the dynamics of this particular mode of production and particularly into capital's creation of a world market and the development of the international division of labour. Many class theorists overlook this crucial dimension with the consequence that in their analysis of class they often offer Anglo-centric accounts of class - for example, Poulantzas and Ehrenreich and Ehrenreichs's assertion of a declining working class abstracts class formation in America and Europe from a broader internationalist perspective. Once this perspective is included one can recognise the massive transformation of pre-capitalist social formations and often pauperisation let alone proletarianisation of whole countries and continents (Warren 1985, Littler 1985).

Summary

Through an evaluation and critical assessment of a number of key attempts to theorise the class position of `intermediate strata' I have shown that none of these attempts adequately capture the class experience of the engineers and systems analysts in my study. I have argued that one reason for this is that the models of class advanced have been too formal and ascriptive - seeking to define class in terms of fixed and formal criteria like voting patterns, job categories, productive non-productive divisions etc., and consequently have failed to theorise class as a relation. Once one adopts a relational model of class then Marx's concept of the `collective labourer' becomes a valuable conceptual tool for theorising the position of the engineers and systems analysts in my study in that it emphasises the domination of the mode of surplus value extraction whilst at the same time capturing the contingent and ever changing relations these groups of workers experience. I have also demonstrated the ways in which the class position of engineers and analysts has an impact upon not only the types of system they design, but on their conceptualisation of their own labour within the process of system design.

Conclusion

Summary of the Main Findings

Most of the organisations studied are using information technology to restructure and rationalise their operations. In particular much information technology is concerned with reducing information processing, packaging, handling, storage, quality and design costs. Information technology is enabling organisations to raise the rate of productivity of a whole new army of white collar and managerial workers; ranging from routine clerks through to designers and line managers.

In one sense the increasing use of new technology reflects the changed terms of competition between firms and the need to cut costs and 'non-profitable' processes and procedures. On the other hand, it also reflects the growth in the organic composition of capital concomitant upon the development of the productive forces under the capitalist mode of production. In a very real sense information technology can thus be seen as the renewed domination of dead labour over living, of capital over the working class - and a specific manifestation of the present historical conjuncture.

Within flexible specialisation, post Fordist, regulation and post modern theory information technology is accorded a prominent place. It is often discussed in teleological fashion - presented as a `prime mover' initiating sweeping transformation in traditional modes of production, work organisation and culture - as an omniscient capital systematically removes all obstacles to profitability. In practice, however, different organisations respond differently to the changed terms of competition and balance of social forces that they experience. Some organisations are taking advantage of favourable legislation and labour market conditions to implement new technology, new working practices and radical organisational changes; others, however, are doing the reverse and taking advantage of favourable legislation to intensify *existing* work procedures and practice without any commensurate outlays of capital on new technology or alternative programmes of work restructuring. Change is far more contingent and contested than suggested by many of the sweeping paradigm models. With organisations reassessing and restructuring their operations, one needs to be cautious about asserting sweeping transformation in the mode of production; rather, specific organisational activity may simply be a response to local exigencies and circumstances - in turn a reflection of the current historical conjuncture and therefore open to modification or even reversal.

I have demonstrated how under monopoly capitalism - with its army of administrators, managers and designers - notions of what constitutes good and bad design are arrived at. Through identifying and documenting a distinctive set of values and methods that engineers and systems analysts hold and practice (i.e. formal theory, analytic theory, Taylorism and methods time measurement, control and systems theory, productivism, design purity, technical and business rationality) I have shown that these are one way in which what constitutes `capital's interest' is open to interpretation. Far from being omniscient and having one interest capital is a social system which in its monopoly stages engenders a profound and detailed social division of labour. I have demonstrated that engineers and analysts - key strata within this social division of labour - not only exercise degrees of autonomy within the design process, but also make sense of their own designs and design activity by reference to a specific set of values, methods and practice which constitute a `design culture' or `engineering system'. This design culture reinforces in engineers and analysts a sense of identity and self importance. It also legitimates their claims for status and corporate power, whilst enabling them to make pronunciations on not only what constitutes good or bad design but also what constitutes 'capital's interest' or their organisations interest.

Whilst some of the specific values and methodologies which engineers and analysts hold reinforce the social domination of capital within the production process, others can, at times, serve as point of condemnation of capitalism. I have identified the tension between those who see systems analysis in terms of an engineering discipline and those who see it as a more artistic or managerial activity. The latter are particularly conscious of the fact that too close an identification with engineering could jeopardise analysts' credibility with users and, particularly, senior managers. This tension between `engineering' and `art' permeates the discourse on tools and techniques. Those who are most critical of 'software engineering' solutions are usually those who have most experience, or pride themselves on being able to design systems on the 'back of a fag packet'.

They tend to be the ones who are more sensitive to the analysts' role as instigator and initiator of managerial and organisational change.

I have documented and discussed the controversy over recruitment and skills and have established that recruitment sources vary enormously and that attempts at imposing rigid recruitment criteria tend to evaporate in the context of severe labour market shortfalls of systems analysts. Similarly whilst specific tools and techniques are available to systems managers to tighten control over systems analysts work, by and large there is little evidence that any process of deskilling of analysts is taking place. Even structured methods like SSADM or the latest 4gls and user workbenches are still widely reported by both analysts and managers alike as being no substitute for the skills of an experienced analyst.

By discussing disaster planning I have demonstrated how analysts' commitment to a technicist rationality often comes unstuck in the face of 'recalcitrant users' and that, far from IT being the panacea for organisational problems, analysts may have to recognise that better understanding of the social relations of production is necessary if designs are to succeed. Systems analysts, unlike engineers, have tended to be more organisationally assertive, seizing the language of business rationality and systems efficiency not only to impress upon others their commitment to organisational change but to advance an ideology which presents analysts as the key agents and guardians of change. Analysts tend to see themselves as advancing the 'system's interest' as opposed to the 'particularist' interest advanced by users. Analysts' historic subordination to users causes tensions between the master and servant; these tensions may become more acute as IT becomes strategically more important to an organisation's success.

In discussing the software bottleneck I have demonstrated, through an analysis of a variety of systems design approaches, the difficulty of embodying the social in the technical, i.e. of mapping and modelling the user environment, procedures and practices in software. The software bottleneck reflects the contradiction between the socialisation of the forces of production on the one hand and their continual restraint within the dominant set of capitalist property relations on the other hand. Many of the solutions advocated for overcoming the software bottleneck represent an attempt to socialise the process of analysis and design through harnessing the knowledge, experience, skills and adaptability of a variety of users and designers and through 'opening up' or rendering more democratic the process of design. However, whilst management may seek to 'socialise' the process of design so as to tap into employee experience and creativity and to win their consent to change they can only do so within the narrow constraints imposed by the dominant set of property relations and the prevailing configurations of power.

I have demonstrated that analysts' utilisation of the concept of 'user' weds them to a narrow and at times self - restricting model of organisational power which downplays differences between different types of user and serves to homogenise user activity. One reason why many analysts adopt this narrow definition of the user is that it helps to legitimise their own activity as advancers of the 'systems interest'. It also saves them much soul searching over issues of re-grading, re-training, or possible redundancy that users may face as a consequence of their designs.

Through an analysis of the project team approach to design I have demonstrated how systems staff can cajole users and surreptitiously advance the 'systems interest' as synonymous with the user interest. Many of the values and methods which systems analysts hold serve to reinforce anti-democratic design processes. For example, notions of systems purity are often used to justify excluding union officers or certain categories of users from the design remit in case they 'unnecessarily clutter the system'. Likewise, systems analysts' systemic models of organisational activity reinforce functionalist views of users; consequently anything, or anyone, deemed to disrupt 'the system' tends to be perceived as dysfunctional. Whilst the outward development of participative design technologies and techniques conveys a sense of democratisation within the design process, particularly with recent emphasis on user centred design, many of these techniques in practice tie the user all the more readily to a dominant systems and business culture - one which forecloses alternative dialogue, discourse and design.

The predominance of a technologically deterministic view of change amongst trade unionists, along with their commitment to collective bargaining, has kept minimal employee involvement in the design process. Whilst union officials recognise the need for continual investment in new technology the majority are dissatisfied with the way employers are introducing it, i.e. 'via the back door' and without discussion. Ironically this dissatisfaction stands at odds with union officers' uncritical acceptance of design as 'management's prerogative'.

Union involvement in the design process tends to be confined to traditional areas of collective bargaining - for example resolving working details arising from the introduction of a particular technology, such as job demarcations, staffing or retraining. The unions that had most input into the design process and those that were able to secure formal terms between employer and union were often white collar unions like the MSF. One reason for this is that their members are often strategically placed to effect design outcomes. Overall, however, issues relating to democracy at work, quality of working life and the need to design rewarding jobs are today further from the trade union agenda than at any time since the second world war. The majority of union officers were content to wait for the re-election of a Labour government before they return to these issues.

Whilst the majority of unions have experienced dramatic membership losses over the past ten years, union officers attribute these losses to government policy and recessionary pressures rather than to the introduction of new technology *per se*.

With the exception of officials from the AEU and EETPU, union officers unsurprisingly, were critical of the governments free market philosophy arguing that it was both misguided and damaging to the long term interests of British manufacturing. Most union officers argued that Conservative governments have created a climate of fear and distrust which, with their monetarist policies, mitigates against the smooth introduction of new technologies whilst at the same time inhibits many employers from making the necessary capital investments in new plant and equipment.

There was general consensus from trade unions that attempts to introduce flexible working, personalised contracts and single union agreements represent an offensive on working class living standards and rights. However, many union officials conceded that the trade unions themselves were embroiled in the process. Reasons cited included falling membership patterns (which are prompting unions to poach other unions members), intensified competition for 'representational contracts' from employers, and the growth of a 'new political realism' such as that displayed by the former AEU and EETPU - a realism which no longer acknowledges the need for class solidarity or socialist politics.

British trade unions were unprepared for the onslaught that befell them with the election of the Conservatives in 1979. The trade union movements adherence to collective bargaining and its reformist political programme means that it is weak to resist overtly anti union legislation. Rank and file members, particularly those most vulnerable to victimisation i.e. the unskilled, part time and female workers have consequently been poorly protected.

On the basis of detailed interviewing and observation and through an analysis and critique of several key theoretical debates on class I have argued that most of the engineers and analysts in my study are part of the 'collective labourer'. The collective labourer is not a class, but a concept used by Marx to denote the diversity of labourers and the contradictory socialisation they experience as commodity relations under the capitalist mode of production extend ever wider. I have also shown that which particular strata within the collective labourer carry out either subordinate or non- subordinate functions is contingent on class struggle and the ever changing cycle of accumulation which acts to condition the particular social division of labour at any point in time.

I have demonstrated the ways in which engineers and analysts conceptualise their class position and how this in turn can influence their design practice and their relations with others in the design team and wider organisation. Whilst arguing that the majority of engineers and analysts are part of the collective labourer I have also demonstrated that the majority of those in my study are not class conscious labourers. Consequently, they tend to be implicated, sometimes consciously but more often unconsciously, in designing systems that tend to secure bourgeois class interests within the design process.

Contribution to Theoretical Debates

This thesis examines the process of business restructuring and the role of a key and largely uncharted group of workers within this process, systems analysts.

Given the reflexive nature of the research, no one particular thesis was pursued from the outset. Rather, on the basis of fieldwork and relevant literature, I proceeded to develop (and modify) several theses as the work progressed.

I have argued that many of the key theoretical debates on changes in business and manufacturing are insufficient and based on a limited reading of economic, social and political trends.

Having critically evaluated the process of organisational restructuring and drawn out some of its key implications in chapter one, in chapter two I advanced the thesis that engineers are not merely the blind agents of capital, reproducing 'capital's interest' through the types of technologies and systems which they design; but, rather, that they have autonomy over the design process and that they actively interpret the interest of capital via a distinctive set of values, methods and practice. Not only do engineers have autonomy within the design process but the values and methods which they deploy constitute a design culture which enables them to define their activity and relationship to others within the organisation.

One of my research objectives was to document who systems analysts are and the type of work which they do. Very little hitherto has been written on the work of systems analysts. I have developed a picture of their work, their culture, their role within the design process; their relationship with other organisational members and how these factors influence the systems which they build.

Critically, I have established the ways in which they exercise autonomy within the design process and discussed in detail the ways in which they interpret what, precisely, is in 'capitals interest'.

One consequence of studying systems analysts was that I became familiar with the techniques they deployed to elicit information from users and the ways in which they tried to secure user support for their designs. This opened up a set of issues relating to design and democracy. Through discussion of the software bottleneck I have assessed a range of proposed solutions and advanced the thesis that there is a tension between, on the one hand, the socialisation of the design process (so as to better elicit information about the user environment and be better able to secure user support for the system) and, on the other hand, the need to impose the system upon users. To my knowledge this is the first research to specifically address these issues. Through my fieldwork and my assessment of the different tools and techniques available to systems analysts I have demonstrated the limitations of these tools and techniques and shown how systems staff are implicated in developing an anti-democratic design discourse.

My analysis of union involvement in the design process demonstrates that unions have a low level of involvement and an uneven level of awareness of issues relating to work design. In addition I have argued that many union officers hold deterministic views about technology and design which coupled with their commitment to collective bargaining, produces a discourse which fails to explore the social relations of production. The 'black box' remains closed, i.e. design remains a managerial domain and mysterious. This technicist discourse undermines the importance of employee involvement in the design process as a precondition to securing broader employee rights at work.

My research sought to examine a number of key issues affecting trade unions, including associated changes in working practices, specific legislation, membership patterns and agreements. The existing pattern of collective bargaining and trade union commitment to tripartism and reformism has left many rank and file workers unprotected against employers seeking to introduce new technologies and new organisational cultures. It has also put many unions in the unenviable position of policing and implementing policies which tighten managerial control over the workforce - for example, the signing of single union, no-strike and multi-flexible agreements.

From the outset of the research I was interested in debates on class and, in particular, attempts to theorise the position of the so called 'intermediate strata' or middle class. According to census definition, the majority of engineers and analysts I studied fell into typical middle class categories. However, I became more and more concerned that my findings did not square with this 'typical' categorisation. Consequently I began to focus on this issue. This was done not to prove or disprove specific theoretical debates to convey more accurately the sense of frustration and anxiety that such characterisations were causing many of the engineers and analysts in my study. I was also keen to develop a model which took into account the relational element of class and which tied analysis of class into the broader process of restructuring and capital accumulation discussed in chapter one. Finally, I recognised that engineers' and analysts' perceptions of class had some impact on the systems they designed as well as upon the allegiances and relations they established in work. No analysis of the process whereby systems come to be designed would be complete without an exploration of engineers' and systems analysts' class position and class practices. Through interviewing and participant observation I was able to let engineers and analysts speak for themselves about their class and its impact on the design process.

General Themes Relating to Engineers & Analysts Work

From the outset of the research I was concerned with documenting the work of systems analysts and engineers and in extending labour process debates on autonomy and control. Importantly, I was concerned with opening up what McLoughlin and Clark (1994) refer to as the 'black box' of technology to show how specific engineering values, methods and practice constitute an 'engineering system'. As McLoughlin and Clark (1994) acknowledge there is a dearth of literature relating to this area - the 'engineering system' remains essentially 'mysterious'. However, on the basis of an extensive fieldwork approach and use of a critical reflexive methodology, I have been able to open up this 'black box'; and, importantly, through drawing out several general themes relating to engineers and analysts practice, shed light on the process of design and the nature of engineers and analysts work. It is precisely the diversity of respondents, their individual experience, training, sector, locale etc., which enabled me to weave a rich tapestry of their work. The richness stemming from the number, variety and colour of threads used. In effect the ability to see the 'general' picture as opposed to the 'particular'- is a consequence of the quality and diversity of the 'particular'. Some of these general themes are elaborated below.

First, engineers and systems analysts exercise autonomy within the design process - autonomy over the types of systems that get built and autonomy over the exercise of their own labour as designers. This autonomy is however, relative, it is exercised and circumscribed by both a distinctive set of values, methods and practice and by the specific division of labour, organisational culture and context in which engineers and analysts work. Thus, for example, whilst as professionals many engineers and analysts acknowledge they should have a degree of autonomy over design some analysts felt they could exercise more autonomy than others. For example, one Senior Consultant felt that he needed to be given a significant degree of autonomy and power an 'open remit' if he were to deliver the kinds of systems he felt management needed. That is one reason why he liked working for a leading UK consultancy and why he liked to be invited into companies at executive level. However, even relatively young and inexperienced analysts in 'tightly policed departments' are able to manipulate users and shape the type of systems that get built. For example, one young analyst I interviewed in a Japanese electronics company confided that 'purely for personal reasons' he dissuaded management from automating a particular work process through emphasising in his analysis the unnecessary cost, disruption and loss of harmony that the proposed new system would entail. Likewise a very senior and respected systems manager within a large private utility indicated that it was relatively easy, given his standing, the 'logicality' of the proposed system and a 'decent systems budget', to manipulate various users into accepting his proposed hand held terminal system. This was done through selective presentation of argument, the 'rigging' of project teams, the bringing in of 'outside experts' and plying potential user managers with good food, drink and smooth video presentations.

Most engineers and analysts, however, felt uncomfortable discussing the issue of autonomy. The younger and usually less experienced, along with those working on more 'back end' or detailed aspects of a design, would more readily say that they were 'working to spec' or merely 'executing user requirements'. This would be particularly true if they felt they were being overheard by more senior colleagues. Senior engineers, senior analysts and systems mangers would however, when pressed, acknowledge that not only did they exercise autonomy vis a vis users but sometimes wielded considerable power. Analysts in particular would often invoke crude functionalist systems discourse to justify this exercise of autonomy i.e. they were exercising autonomy for the 'good of the system' as opposed to 'particularistic' user interests. For example, one senior analyst in the aerospace industry prided himself on his ability to exercise 'autonomy' in a 'balanced way' arguing it would be dangerous to let a 'rookie loose on users' because such a person would not have the intimate knowledge and experience of users at that particular plant. The more senior systems analysts, production and industrial engineers recognised that their work was in fact highly political. They were making choices affecting not only the quality of working life of employees using the system but the viability of the organisation itself. For example, one consultant analyst argued that it was precisely the 'political nature of the work' that attracted him to the job, he could use his position to get things done. His status, power, large salary, expensive car and high living standards were in his opinion a necessary part of the package. Likewise, an industrial engineer in the chemical industry argued you need power and autonomy to 'cut through the bullshit', 'get things done' and 'overcome' the 'obstinate and obdurate characters one comes across in this business'. The consternation felt by the majority of engineers and analysts, however, when discussing autonomy stems from the fact that, on the one hand, they present themselves as 'servants' of the organisation, 'unbiased professionals' 'committed to the user function'; whilst, on the other hand, their implication in a specific design culture incorporating the dominance of systems and control theory, technical rationality and design purity, acts to justify their intervention in that process in the name of some higher good.

The exercise of autonomy is contingent on a variety of factors, for example, size of project team, composition of project team, degree of management monitoring, tightness of management's initial specification, size of budget, type of sector and scale of system being built. Thus, for example, one systems manger in the highly competitive software industry indicated that he had been forced to introduce a variety of software to monitor the autonomy of a number of his programmers and analysts with the specific intent of raising their productivity. He recognised, however, that this could be counter productive because too tight a control over their labour was resulting in 'work to rule' attitudes and 'loss of flair'. He was also concerned that given the labour market shortfall of IT professionals he might alienate and lose some of his better analysts if he pushed too far down this road. A group of analysts in the aerospace industry argued that at one point there was so much government money flowing into the department that 'all kinds of wacky projects were underway' and analysts were given free reign to exercise their ideas. However, with the onset of recession, falling government subsidies and the 'ending of cold war', budgets dried up and management became more active in cost benefiting designs and tightening up control.

Second, engineers and analysts share a design culture which emphasises the unpredictability, uncertainty and volatility of human labour. They are taught through exposure to particular methods, i.e. formal logic, analytic theory, scientific management, and control and systems theory, to control and preferably eliminate human labour from any given system. The critical assumption of formal logic is constancy and the need to engineer 'stable systems'. This is reinforced in analytic theory through emphasis on 'scientific detachment' and 'rational' analysis - the assumption being that if each part of the system studied is perfect then the whole must be perfect too. Following from this tradition and likewise reinforcing it is Taylorism and Methods Time Measurement with their emphasis upon the efficacy of detailed division of labour and tight control of 'operating units' so as to minimise uncertainty. Control and systems theory expand upon this discourse by providing the theoretical rationale for a detailed division of labour based upon the separation of conception and execution of tasks in which a specialised group of workers (i.e. designers) are privy to a specific body of knowledge - 'design science', which they use to rationally construct 'scientific' work systems. Engineers and analysts involved in a wide variety of different system designs across a variety of sectors were influenced by these assumptions, though age, experience, position and the type of project being worked upon all influenced their views. For example, with the introduction of graduate training programmes and the increasing reluctance of companies to take on non-graduate labour, there has been a breaking of more traditional craft routes of entry into engineering and analysis. Under the craft route many engineers and analysts grew up in a close relation to the shop floor and to users. A number of older and more experienced engineers and analysts argued that this made them 'less proselytising', 'opinionated' and 'arrogant' than the 'younger graduate breed' and consequently they felt less 'elitist' and driven towards the subordination of shop floor workers. They felt that because they were not exposed to the same bodies of theory and because there was not the same rupture between theory and practice as there is for graduate entrants, they were less 'fearful of going onto the shop floor' or getting too close to users. One analyst, for example, was adamant that 'coming from a working class background' enabled him 'to do the job better' and 'give him more insights'. Likewise, another analyst stressed that because he had worked on the shop floor he couldn't 'be ridiculed or 'have the piss taken out of him' so easily as 'some college nosed graduate'. A minority of engineers and analysts are, however, more critical of cruder systems discourses which fail to give due recognition to the satisfaction of human needs. Their more critical design stance can emerge as a result of some moving hands on experience with a particular group of users. Thus, for example, one designer working on a project for handling toxic chemicals argued that `working alongside workers on the line and getting to appreciate their job, its dangers and their fears over loss of skill and their need to feel useful' affected him; and that, consequently, he `will never feel the same again about design and all that Taylorist power shit'. For this designer, at least, this meant a rejection of much of the theory of control and deskilling he had been taught at college.

On the whole, however, these values and methods create such a culture of control that engineers and analysts invariably seek to minimise human override and disruption of their systems. This is reinforced through particular practices, for example, one analyst argued that college played a crucial role in inculcating in him that you do not design `open loop' systems when `closed' ones will do the trick. His college lecturer deducted marks from students who introduced such `uncertainty' into their systems. The degree to which engineers and analysts see human labour as dysfunctional or a source of added workload or stress also depends on a number of other factors including the type of user of the system, the amount of time allowed for systems development, the type of system being built, size of budget and particular organisational cultures. Thus, for example, one systems analyst in the financial services sector argued that analysts will devote more man-hours to the design of systems for management than they will for lower level users. Management tended to pride themselves on having more powerful systems with 'more bells and whistles' and practising analysts quickly learn it is best to 'placate them' even if this means spending less time with lower level users. One industrial engineer explained that the reason he did not design rest bays on the production line of a steel mill or devote much time to noise dampening was that the 'Welsh workforce are fat lazy bastards' and that 'they should be there to work' not 'rest and be pampered to'. Clearly, this designer had no qualms that his designs reflected his opinionated, nationalistic and anti-worker philosophies. By contrast, several systems analysts working in the automobile industry indicated that it would have been possible to introduce systems which gave machinists 'more autonomy and control over the inputting of data into the system' but because of a change in management and the appointment of a 'particularly right wing chairman' who made clear his intent to rationalise and streamline the works, their systems manager advised it would be best to 'override manual inputting of data'.

A number of analysts pointed out that the shift towards complex real time systems had necessitated greater awareness of human issues and the need to incorporate user requirements into design build. Certainly analysts, more so than engineers, had a more sophisticated systems discourse in as much as they considered the needs of users more fully within systems design. However, as argued in Chapter 4, the tendency is still to incorporate the user within the system: that is, to wed the user to the system in such a way that the 'functionality of the system' is not impaired, i.e. 'the system' is not jeopardised.

This need to incorporate users to the system was articulated by systems analysts and systems managers across all sectors and organisations. An analyst working for a multinational electronics company stressed that 'too close an identification of interests with those of lower level users will be rewarded with lack of career progression, unrewarding projects, back end and routine analysis and a closing of senior user ranks'. Likewise the systems manager of a large public utility argued that 'Its important to get users involved....but you have to appreciate which (of their) suggestions and information is functional to the system'. Despite the diversity of sectors analysts are located within and despite differences in age and experience the notion of incorporating users needs in such a way as not to jeopardise the systems interests was striking and indicated the strength of systems discourse and the notion of 'guardianship' that many analysts felt.

Third, engineers and analysts work is infused with a technicist rationality. Engineers and analysts have a strong faith in the capacity of technology to solve human problems. Importantly, despite the acknowledgement by some engineers and analysts that design is a political process, the majority take account only marginally of the human, social and political elements of systems. Unsurprisingly, both engineers and analysts perceive the accumulation process as a technical process and accounting and profit as indicators of system success, rather than as indicators of labour exploitation. Because accumulation is seen as a technical rather than a social process, engineers and analysts tend to perceive their own work in likewise technical terms. It is they who ensure that inspection, monitoring, overseeing and control of organisational functions are carried out `effectively'. Often engineers and analysts justify designs in terms of lesser evils invoking spurious notions of `technical efficiency' to justify particular systems designs that may have led to job loss, work intensification or deskilling. Analysts in particular tended to see themselves as information technocrats and were far more proselytising in their desire to spread the technical creed. Many analysts believe they are riding a technological tidal wave as computerisation sweeps through the international business community.

However, a number of more senior analysts and systems managers pointed out the dangers of this technicist credo suggesting that maybe more IT is not always better; these were the ones who prided themselves on being able to say `no' and who recognised the possible fragility's of computerised work systems. They were also the ones who tended to emphasise their organisational and business skills distancing themselves from younger and presumably less experienced `techies'. Thus, for example, one systems manager who had worked in the automotive components industry for over 20 years, doing a variety of jobs including engineering, argued that on the basis of his experience of the local workforce and his knowledge of the plant there have been times when he has `squashed' plans for more extensive systems development on the grounds that such developments would either upset industrial relations or were not justifiable `given the companies product structure and the nature of the market'. He also felt that this was why senior management put him in charge of systems because they new he was not a simple `techie' but had rich and detailed knowledge of the plant and its personnel. Likewise, a senior analyst within the aerospace industry conveyed how he and the systems manager agreed with auditors that the company was too reliant on computer based information flows and that a more manual paper based system had more robustness. According to this analyst he was one of the first to bring to the attention of management their over reliance on mainframe systems. He argued he could do this because for him being an analyst was more than being a 'techie' it was recognising what is good for the organisation and what the limits and weaknesses are of particular designs in specific contexts. A number of senior analysts, systems managers and consultants prided themselves on having organisational and business skills and not just technical skills. One consultant insisting that this was the major pre-requisite for the job. Similarly, a systems manager in the financial services sector conveyed how some of his younger analysts are organisationally and politically inept, and, how, in their desire to extend and develop systems further, they alienate users and bring ridicule on the department. Engineers were generally far more prosaic regarding the benefits accruing from IT and were more critical of the ways in which technology was being used to tighten up accounting procedures and rationalise organisations. Indeed many engineers were on the receiving end of this technology and process of rationalisation both in terms of its impact on the quality of their own work, on employment levels and on conditions and status. For example , one engineer in the electrical engineering industry highlighted how his own work had become devalued and more tightly monitored with the introduction of CAD/CAM, and report generators. Another engineer working in the chemical industry pointed to the lack of job opportunities and interesting projects in engineering with the run down of heavy industry and manufacture. Engineers in a variety of sectors generally felt unfairly treated compared to analysts - who were seen to have less skills, education and training yet more pay, status and decision taking responsibilities. However, not all analysts felt they were riding the crest of a wave and some, particularly in the more traditional manufacturing industries or those which had, as yet, made little investment in IT, felt far from privileged and were far less sanguine about the benefits accruing from IT or their own career progression.

Fourth, business rationality is rapidly becoming the new altar upon which systems analysts, in particular, worship. The majority of younger graduate analysts and more senior analysts and systems mangers would justify their autonomous decisions, including less IT if necessary, in terms of their understanding of what the organisation needed. For example, the systems manager of one private energy utility stressed that because the systems department has 'its fingers in every other department' and knows their business' this makes them 'more than anyone else know what's best for the company'. In those organisations with large systems departments and a prominent IT function such sentiment was common place but even in smaller establishments similar viewpoints could be found. Thus the systems manager of an automotive components supplier that had recently developed a supplier/customer data base sharing design and product information, stressed that as more business functions move onto the mainframe systems, 'part of a global transformation in manufacturing', then 'systems staff more than anyone else are in a good position to take a strategic overview of business needs', they are able to see the 'general as opposed to the particularistic'. Analysts definition of an efficient system invariably uses a narrow range of indicators like cost savings achieved or productivity gained. Analysts use notions of business rationality to explain away their designs. Particularly in the private sector analysts would often invoke the market and market forces as the ultimate arbiter of system worth. For example, one systems analyst in his late twenties working for a leading Japanese white goods company justified the system he had built on the grounds that 'if I didn't build it this way, the market would penalise us all [and] we just wouldn't be competitive'. At a practical level unitarist perspectives like business rationality, save analysts a lot of soul searching, the market can always be invoked to justify why an analysts had to produce a particular design. For example, a systems analyst working for a major high street bank argued that 'in banking a lot of our systems were designed expressly to shed labour and increase productivity...it is unfortunate but it has to be done if we are to remain competitive and efficient'.

A number of factors are responsible for the rapid rise of this business credo within systems design including the fact that, almost without exception, the companies and organisations I studied, including those in the public sector, had experienced recent processes of restructuring both in terms of job losses, changes in working practices and rationalisation but also in terms of greater executive emphasis on new organisational cultures stressing 'cost effectiveness', the 'reduction of waste' and 'slack' and the need to end 'restrictive practices' and meet 'customer requirements'. Analysts immersion into dominant business cultures has also been greatly reinforced via government, trade and media emphasis on the virtues of competition and the free market, importantly here, many analysts are at the cutting edge of a technology which is being used to rationalise and which is expected to deliver improved market performance. Analysts own career progression is intimately tied into senior management's perceptions of analysts understanding of business and their organisational and communication skills. Finally, graduate recruitment with its increasing emphasis upon business and organisational skills within degree and course curricula has fostered a culture in which graduate analysts see themselves as part of management and anticipate managerial rewards.

Whilst many analysts are ready and willing to be incorporated into the business community, others, however, were far from happy at the prospect of entering that community or having their work presented in such overtly business orientated language. These tended to fall into three groups first, more experienced senior analysts and managers that had usually been within the same company for a long time and who felt that the proselytising business rhetoric and image of their younger analysts was alienating users and consequently making systems design more difficult. Second, a minority of analysts and systems managers who for personal or political reasons did not either want to be embroiled in the new competitive business credo or design systems which had as their sole rationale the increasing of dividends to share holders. Third those who were working in more traditional manufacturing industries or tightly costed public sector organisations with little investment in IT or generally within small systems departments. For example, the systems manager of a heavy electrical engineering company argued that his younger analysts `modernise, modernise...efficiency savings here, cost savings there' attitude were not only `alienating users' and making him `cringe' but fostering a climate of unnecessary uncertainty and disgruntlement which was making his job harder. One senior systems analyst, working in the public sector, indicated that he had turned down lucrative job offers in the private sector because he did not want to be part of the `nineties' competitive business culture. However, even he recognised that his values were being compromised with the pressure to save costs and deliver `sub-optimal systems'.

Fifth, both engineers and analysts utilise the concept of design purity in a number of interesting ways. Whilst many engineers invoke the imagery of Italian engineering to epitomise design purity, systems analysts tend to utilise Weberian notions of technical - rational efficiency. Ironically neither engineers nor analysts could accurately pinpoint what precisely constitutes a pure design although all could cite examples of pure designs. Pure design was invariably something in which `form followed function', that had `singularity of purpose', that was not `too pinickity', or `over engineered' and that had `logicality' and was `uncompromising'. Engineers and analyst no matter what age or what sector they were in recognised design purity and their own personal and sectoral experiences helped them furnish examples of this purity. Thus the chief design engineer of a heavy electrical engineering company argued that the `Italians are renowned for their pure design philosophy, unity of form and function, singularity of purpose. It gives their products charisma, it sells' he then goes on to stress that unfortunately he has had to design things which have not been at one with his 'instinct', which have been 'compromised'. Likewise a design engineer in the machine tool industry stated with pride that the latest drill bit he had designed was not compromised in its design 'its pure engineering'. Similarly a systems developer at a regional water authority argued that 'systems should be efficient.....they should have singularity of purpose...ideally they should not be compromised and cluttered with too many bells and whistles....which require inordinately long programming hours and, anyway, divert the user from the task in hand'. Another systems analysts in the financial services sector argued that, 'You do not compromise the design of the system just because of human factors'.

The concept of design purity is used by engineers and analysts not only to pass judgement on a particular product or system but to pass judgement on others involved in the design process. For example, a number of systems analysts interviewed at a US electronics company conveyed their dismay with management at the plant arguing that the system was compromised because of lack of funds and short sighted management strategies. In effect notions of design purity serve to reinforce in engineers and analysts a particular notion of their own labour and their relationship to others within the organisation. Engineers and analysts notions of design purity can be used to condem short sighted management who presumably would not know a pure design if they tripped over one; and at the same time they can be used by engineers and analysts to justify building a particular artefact or system the way they did. In practice I found that engineers in general, and particularly those located in the older industries and manufacturing sectors, used concepts of design purity to critically distance themselves from what they perceive as a 'gin and tonic' management who were seen to be 'unprofessional' and 'misguided in their strategy'; and often directly responsible for engineers own lack of status and career progression.

In effect engineers and analysts advocate design purity and in so doing distinguish themselves from non-engineering management. Ironically, when pressed, both engineers and analysts will admit that design is a compromise yet they still adhere strongly to the notion of design purity. Indeed it is the very uncompromising nature of some of the most pure designs cited which, for engineers and analysts, at least, gives them 'purity' status. One possible explanation for this is that notions of design purity help to constitute a particular world view which, in turn, reinforces in engineers and analysts a sense of their own self worth serving to legitimate their calls for privileged status. Notions of design purity also serve as ideological props, enhancing engineering mastery not only over nature but mere humanity which presumably should stand in awe, if not fear, of some of its most pure designs. Thus for example, many engineers and analysts I interviewed took a perverse delight in talking about some of their most pure designs - designs which invariably were feats of intellect and creativity and which they clearly wanted respect and recognition for producing. The concept of 'pure' engineering certainly represents an idolatry of engineers own labour as uncompromising, practical and purposeful activity and in this sense notions of design purity serve to establish engineers own identity *vis a vis* the shop floor and management.

Sixth, engineers and analysts across a variety of different sectors, including manufacturing, finance and retailing, conceptualise their work in productivist terms. The analogies with coal mining and getting down to the coal face and getting ones hands dirty, frequently entered into engineers and, more suprisingly, analysts discussion of their own work. Thus for example, one design engineer in his thirties in the aerospace industry argued that unlike much of management, stuck in the office, `I see myself as a practical person, designing and building useful products...not just dreaming up ideas and strategies but actually implementing them and producing something useful'. Likewise a young systems analyst in the automotive industry was insistent that `we don't just sit around pushing pens...we get down to the coal face - talk with users...get things built'. Whilst yet another analyst in the financial services sector stressed that `our work involves us getting our hands dirty'! Those engineers who drew greatest pride from the productive nature of their work tended to be the more experienced and in particular those who had come up through the craft route and who were more directly engaged in the practical side of engineering. Younger graduate engineers were often ridiculed by more senior engineers and shop floor workers alike for being `elitist' and `not wanting to get their hands dirty'. However, I found that even the younger graduate engineers, particularly if in recessionary sectors, quickly drop their elitism as familiarity with management practice, lack of interesting projects and career progression makes them jaded and cynical.

Similarly, younger graduate analysts tended to be more guarded about the productivist nature of their work. Whilst taking pride in the fact that they were not mere pen pushers or 'office wallies' they were more careful about making too close an identification with productivist values particularly if these might be seen to be associated with lower level users. Thus for example, one analyst in the financial services sector had no trouble talking about productivism because he was confident that this term did not carry the 'working class connotations' it might in more 'traditional manufacturing sectors'. Discussion of analysts tools took on similar productivist and macho overtones. Tools and techniques were invariably described in terms of 'toolkits' with the emphasis placed upon their 'engineering content'. Thus one analyst at a major high street bank argued that 'I have my own personal toolkit which I prefer to use and other analysts have theirs...which particular tools you use depends upon the situation you are modelling'. One could be forgiven for thinking analysts, unlike many engineers, actually had a bag of tools which they carried round from job to job when in fact the tools they are referring to are often paper methodologies and computer software which do not as a rule leave the systems department.

Whilst attachment to productivist values may constitute a vital distinction for many practising engineers and analysts between their labour and that of others within the organisation many senior engineers and analysts were wary of too strong an identification of their work with the vocabulary of productivism. This tended to be particularly so for senior systems analysts, systems managers and chief design and industrial engineers who felt that too close an identification with productivist cultures would discredit them in management's eyes and reduce them to 'technical status'. Thus, for example, the systems manager of a major pharmaceutical company cautions those trying to advance the cause of systems in productivist or engineering terms arguing that 'analysis is more managerial requiring inter-personal and organisational skills as well...its unhealthy to make too close an identification with production'.

Whilst engineers in the UK have been immersed in a culture of productivism, a culture encapsulated in Taylor's belief that management knowledge should be rooted in the 'science of productive processes', my research suggests that analysts are becoming less wedded to productivist values than engineers and more assertive in their claims for managerial recognition. Some of the larger organisations, in an attempt to retain skilled personnel, are addressing this tension by offering 'equal status' career routes for those analysts happy to focus on the more technical side of their work and for others who want to develop more managerial skills. Thus, for example, the systems manager of one large private utility argued, 'companies like ours that can afford to retain the best staff have begun offering equal status career routes. That is, if you're the kind of personality that likes the technical side of systems you will be duly rewarded in terms of pay and status, equally, if you want to develop the more personal side of analysis you will be given equal opportunity'. However, dual career structures are hardly likely to bridge the cultural differences between technical and managerial careers and the higher status and rewards that attach to management.

Seventh, analysts across all sectors i.e. manufacturing, finance, retail, have a narrow definition of users, one which fails to recognise user diversity and heterogeneity and the real possibility that interests of users may not coincide - not even within the same department or function - and that clashes of interest and antagonism can arise between users. In one sense this is unsurprising as both systems literature and practice fosters a dualist discourse emphasising two key players analysts and users. One possible reason for the simplicity of this discourse is that to recognise the diversity and range of user interests and to recognise the possible sources of irreconcilable interest is to overburden and increase the complexity of systems analysts tasks and risk shattering their essentially functionalist and systemic organisational model. For example, an experienced systems manager at an automotive components manufacturer felt that many younger inexperienced analysts could not handle the politics of systems design because they don't have sufficient practical experience of different users and of how to manipulate and balance the interests of different users etc. This manager argued that that is where more senior systems staff should step in to lend a guiding hand. Likewise, in some organisations relatively inexperienced analysts who have been working to supposedly fool proof methodologies have made fools of themselves and other more experienced systems staff through following dogmatically rules and procedures and failing to recognise or accommodate different user cultures and interests. Indeed, the more senior analysts and systems managers stressed that a primary reason for their seniority was their political awareness and in particular the fact that they had a more sophisticated user model than the one shared by many practising analysts in their departments. Thus for example, a senior analyst in the automotive industry suggested that it was only because of years of service to that company and because of the detailed knowledge and contacts he had built up among a wide variety of users within a range of departments that he was rewarded with senior analyst position. Certainly this analyst had the respect of the younger analysts I interviewed in the department, some of whom openly acknowledged that they called on him when they were unsure of particular users or how best to approach them. According to one senior designer in the pharmaceutical industry recognising user diversity and clashes of interest can be too much of a headache for some of the younger staff who sometimes just wish they were 'dealing with the technology as it is less troublesome'.

Reinforcing the narrow definition of users so prevalent in systems literature and practice is the fact that historically IT has played a secondary role, a supporting role to the business function. IT has thus grown up in a close relationship to user managers and heads of business functions. Systems origination, funding of projects and setting of requirements is thus a process influenced historically by business users. As one analyst candidly argued this closeness to the business function can 'obscure clarity' and prevent one from 'speaking to Joe down on the shop floor and maybe once in a while designing something just the way he would like it'. The commodification of software packages, tools and techniques used for modelling the user environment further reinforces in analysts a narrow systemic, functionalist view of the user. Not only do many of these packages have a narrow definition of the user - usually management, but they guide the analyst into a particularly narrow discourse with the user - one which has as its premise the need to incorporate information from the user and possibly the users themselves into the proposed system. Ironically it was reported to me by several analysts that the larger organisations with more systems staff and larger systems budgets, tended to push younger and therefore less experienced analysts onto these packages and encourage them to build systems according to the strict procedures laid down in them. One senior analyst in the automotive components industry was adamant that this was one reason for so many failed systems and dissatisfied users and that 'ironically design tends to be better when undertaken by knowledgeable in-house analysts who know the users and their culture'. In as much as analysts need to accurately model users in order to build systems they need an approach which enables them to get down to the 'coal face'. In practice, however, many analysts are not too concerned about speaking to 'end users' and satisfy themselves with speaking to user managers. It is user managers who 'sign off' the systems and who's needs and interests tend to be met within the design build. Importantly user mangers needs may not coincide with those of end users and systems analysts are wary of antagonising user managers by building systems which challenge their authority and interest.

Eighth, despite the plethora of approaches advocated for ensuring good systems design, the approach most favoured by analysts was the project team. The majority of analysts I studied felt that so long as the project team comprised individuals with complementary skills then problems relating to the general inability of any one person or tool to embody the full range of required knowledge and skill could be overcome. However, a minority of analysts disagreed, for example, one analyst cited in the text argued, 'it is naive to assume that the project team simply because it comprises suitably skilled and experienced personnel is thereby going to design good systems'.

In practice project teams differed enormously, in both terms of skills and knowledge prevalent, and in terms of choice of 'right' project team members. For example, one systems manager working within a small division of a regional health authority argued that there was such a shortage of analysts in his department and no money forthcoming to 'buy any in' that he was 'forced into asking one of the departmental secretaries' to do the analysis, 'basically I briefed her on the proposed system, told her which users to approach, who to look out for, and what questions to ask....fortunately she has worked here a long time and has an easy going personality which relaxed users...and I could deal with the more technical side.....but obviously the analysis could have been done better, having said that though the users were satisfied with the system we delivered. It just needed a bit of fine tuning'. By contrast a senior analyst within a large financial services institution said he worked on a project where there were' too many specialists' and 'know it all's' each wanting to pull the system in their own direction and none capable of resolving their differences. In that instance the problem was 'solved' by the systems manager and auditor 'laying down the law' and saying this is how its going to be done. Likewise, the systems manager of a major public utility argued that some organisations with too much money to spend often bring in outside consultants and experts when there is little need to do so. When in effect all the work could have been done in house. According to this manager large companies often do this to legitimise a strategy they want. However, this can cause friction and bad feeling between in-house staff and outside consultants. One analyst in a major private utility argued that on one occasion so bad was the friction between outside consultants and in-house systems staff that the project was `set back some several weeks at a cost of thousands of pounds a day'.

Project teams also differed in terms of size and resources and this could have a dramatic impact upon the quality of systems developed. For example, one analyst in a major public utility argued that because of tight budgetary constraints imposed by central government less time was spent talking to users and getting their requirements than should have been and also that the project would have benefited from some experts in ergonomics but because of lack of funds they were not brought in. Many analysts stressed that their best work was undertaken in small project teams in which the systems department co-opted strategic users into the team for a couple of months. Other analysts felt that large projects necessitated significant financial backing and detailed project management but that many organisations, even the large ones, were often unwilling to provide the necessary financial and personnel resources. Some of the larger organisations I studied in the banking and financial services sector were directly addressing this issue by creating corporate IT directorships and ensuring that IT was given financial and political recognition. Projects are also often steered or led by one or two powerful individuals who either through position, backing or knowledge are capable of capturing the ideological highground and steering the project down a particular path. For example, on one particular large scale project in a major private utility the systems manager had struck up strategic allegiances and already persuaded key corporate personnel of the merits of his proposed system even before the initial project team was chosen and the system issues discussed with the respective user managers of the functions to be affected, this attention to detail was then carried over into careful choice of project team members, aids, support and background preparation. A senior analyst on the project stated openly that without securing corporate backing and finance the money wouldn't have been forthcoming to bring in all the experts and to produce the necessary background research and documentation, not to mention to provide plush luncheons and good drink. In smaller organisations with less money and in which the systems function is still seen as some what peripheral to mainstream business systems managers may have to work a lot harder and be even more cunning and manipulative if they are to convince senior management and strategic users of the merits of a particular system. Thus for example, one systems manager, in the automotive components industry, reminisced with pride how several years ago, 'before systems really took off,' he was working on a project that had virtually no financial backing, in an organisation that had maybe six or seven linked PCs and a couple of cnc machines and a 'stay as we are culture'. According to this manager trying to persuade anyone of the need for change let alone get them to be part of that change process was an uphill struggle. However, he prided himself on being able to use his knowledge of the workforce and different users and a small but dedicated systems staff to get the company to accept the need to move towards a more integrated just in time system of manufacture.

Project team success is related to systems success which in turn is often conditioned by prevailing notions of profitability and efficiency. The irony, however, is that what may at one time have been thought a successful system, may at another point in time be seen as sub-optimal. Thus for example, one analyst in the aerospace industry recalls how some of the projects he was working on in the mid seventies were infused with an 'automate everything that moves mentality' which if displayed today would mean 'we wouldn't even be trusted to clean the floors'. Furthermore, what may be seen as optimal from the point of view of certain project team members may not be seen as optimal from the point of view of users. More to the point project team success is measured, amongst other things, against whether or not senior management and executive decision takers are happy with the outcomes i.e. did the project team meet its objectives. Analysts argued that project teams which delivered systems which did not meet, or indeed undermined, corporate goals, could expect to be dealt with severely by senior managers and corporate directors. For example, one senior analyst in a large private utility, recalls how he was working in a project team which was 'toying with the idea' of raising employee 'commitment and productivity by giving them a degree of discretion and decision making responsibilities which were previously held by supervisory grades'. However, when 'senior management got wind of the system they came down on us like a ton of bricks', all team members were reprimanded and the project team was disbanded. Obviously larger organisations with large systems departments offer the potential for the cross fertilisation and trying out of new ideas, ironically, however, they also tend to be the ones who seek to impose structured methods, detailed control and who come down hardest once offended. Interestingly, in the example above, this did not mean an end of project team autonomy within this organisation, rather from that day on, `systems staff learned to play the cards closer to their chest' and `keep designs to ourselves'. Even where project teams are tightly monitored and audited, analysts through a variety of means including - keeping the project team tight, utilising technical discourses to whitewash over recalcitrant users and subtly persuading management that the system they are advancing is in the general interests of the organisation - can secure their interests and exercise autonomy. Importantly, I found that systems managers wanted teams that were `tight', `knew the game' and were capable of manipulating others rather than being `manipulated by them'. It seldom occurs to younger analysts to question the validity of project origination by senior management, likewise they do not readily question the origination of the project team or the methodology deployed. To question this would be to question the system perspective which they hold and the rationale of their own labour within that process as deliverers, servants and guardians of the system.

Ninth, the increasing complexity of systems being modelled has pushed analysts into seeking greater user participation in the design process to be better able to map, model and modify the user environment. This is particularly true of those organisations who are moving towards complex computer based systems of design, manufacture and sale, but is also true for organisations who are seeking to utilise IT in a more holistic way to tighten and rationalise procedures and administration. Thus, for example, analysts within the banking and financial services sector are heavily engaged in the process of rationalisation and restructuring within those sectors and are often at the forefront of analysis in the sense that they are trying the techniques and packages for systems modelling and analysis and requirements setting. These organisations also tend to have more money and resources made available to systems departments. By contrast in some of the smaller and medium sized establishments analysts reported little change in practice. Whilst recognising the need to accurately map user requirements and get user commitment to systems they often did so through more traditional means of pencil and flip charts and through using their personal contacts and relations with users. These were also the organisations which tended to produce the characters who prided themselves on being able to design complex systems on the bag of cigarette packets. A participative approach to design is not however, the same thing as democratic design. None of the participatory user centred design strategies secure the democratic participation of users in the design process. Furthermore, the use of structured methods and sophisticated modelling software by many of the better funded systems departments, usually in the larger organisations, actually inhibits this democratisation by structuring the problematic in such a way that the user is seen as a site of dysfunctionality and uncertainty. I found that whilst user participation is useful something's are more sacred, namely ensuring that system requirements are met, These requirements are invariably set by managing directors, senior consultants, or senior user managers and senior systems staff. Much will depend upon the organisation and the scale of the system. For example, large scale projects such as that initiated by one of the major private utilities I studied, tend to originate in 'secret' meetings, in this instance between a couple of corporate directors and the systems manager, with the systems manager doing the initial introduction. Only after being given the green light by these personnel did the corporate machinery begin to turn and the resources and money begin to flow into the project and away from alternatives. In smaller companies analysts have reported a more 'open' process of system origination, but even here they recognise that open is not the same as democratic. Thus, for example, one designer in a medium sized electrical engineering company indicated that on the basis of his local knowledge he took the decision not to 'frighten the workforce' through disclosing the full extent or possibilities of the proposed system.

System requirements are defined in an undemocratic way but their realisation invariably requires detailed involvement of different types and levels of user, with the design usually taking place in an atmosphere emphasising co-operation and commonality of interest. In the larger organisations this make take the form of large presentations, the assigning of large numbers of analysts to different users or the co-opting of users onto different project teams. In the smaller organisations it might simply reduce itself to an informal chat between the systems manager and a couple of users and their manager. In either case, opposition, where it is met, is generally presented as impersonal and discussed by systems staff in terms of its dysfunctionality. Obstinate users may be pacified in a variety of ways depending on the organisation, the type of user and the resources at the systems departments disposal. For example, on the project cited above at the major private utility, some very senior user managers had to be persuaded to come over to the side of the system this was done by the systems manager bringing in selected personnel from other divisions which had used the system experimentally, through bringing in personnel from the ministry of defence to prove the integrity of the equipment being suggested, and through bringing in big gun names from highly respected private consultancies. In other organisations users have been persuaded by cheaper and possibly more cost effective ways. Thus, for example, the systems manager of an automotive components manufacturer, explained that he likes to keep things small and personal, take 'worried users to lunch', 'relax them over a pint', 'spend more time explaining things to them', 'talk about the rugby game that weekend, or holidays etc.'. This was relatively easy for him as he had been with the company thirty years and the company is the main employer in what is only a small town. When all else fails systems analysts can get hard headed and drag out the systems and technical/business discourse. For example, one analyst in the white goods industry felt compelled to tell a number of users that if they did not accept the proposed system the company would fall behind its competitors and hundreds would then end up losing their job and not just twenty or thirty. Analysts seek user participation but they are wary of the very users who's participation they seek. The older more experienced analysts pride themselves on being able to not only extract information from users but at the same time win users over to the proposed changes. With the increasing commodification of analysis and design - the use of standardised analysis and design methodologies, design software, etc., the scope for exercising this personal flair may diminish, particularly for analysts working in the larger more centralised systems departments. A number of analysts in the larger organisations and particularly those in the financial sector felt this process was already well underway.

Implications of Findings for Current Research and Practice

1) Engineers and analysts exercise autonomy within the design process. Yet the bulk of the engineering and systems literature and of practising engineers and analysts does not acknowledge this. This has a number of implications for the organisation and control of engineers' and analysts' work and on the tools and techniques which they deploy. For example, attempts on the part of certain institutions and managers to impose either 'software engineering' or structured methods approaches, with their emphasis on 'de-politicising' the design and decision taking process, do not square with the reality of engineers' and systems analysts' practices they result not only in contradictions and antagonisms in the education and training programmes for these groups but also in problems for practising engineers and analysts. Consider, for example, their professionalisation and status. Do they acknowledge their artistic, creative and intuitive role within the design process and develop similar strategies of advancement to management, or do they acknowledge (often in the face of practice) that they are merely technicians wielding tools in a non-creative

fashion, and resign themselves to the status of technicians? In many ways an overemphasis on merely technical attributes and skills at the expense of emphasising political, social and managerial skills has already cost engineers dearly in Britain in terms of their low status. A significant number of senior analysts and systems managers were conscious of the fact that attempts to impose software engineering solutions and structured methods are not so much an attempt to de-skill them but to undermine their status and credibility with senior managers.

2) Engineers and analysts conceptualise their relationship to the design process and pass judgement on the validity of the systems they design and the use and worth of their own work by reference to a distinctive set of values and methods. There has been little research in this area and there is a dearth of literature dealing with these issues. This is ironic given that these values and methods serve such a vital, if (at times) unconscious, part in determining not only the forms of intervention and types of systems that engineers and analysts build but in establishing their own identity and defining their relationship with 'users'. Neither the engineering, analyst or management literature has focused on these issues, so our understanding of the culture and practice of design and of designers remains limited. This is all the more alarming given current managerial preoccupation's with 'manufacturing excellence' and 'design for manufacture' with an emphasis on getting design and build 'right first time'. It would seem appropriate at a time when design becomes increasingly critical to business success that attention be drawn to the values, methods, tools and techniques

designers use and how these have an impact upon the types of designs and systems that get built.

3) There is a tension between the development of tools and techniques designed to elicit more accurate representations of the user environment and the need to preserve existing bases of power and authority. The majority of analysis techniques do not address the fundamental issues of power within organisations. Analysts operate with a limited conception of the user and the system which undermines their attempts to model more accurately and (importantly) to embody different user perspectives within the design. Given that millions of pounds a year are spent on developing tools and techniques to more accurately model the social in the technical it would seem appropriate that designers address their own limited methodologies and ask why, despite the reality of their own practices which recognises user complexities and power interests they still utilise relatively wooden functionalist conceptions of the user environment and of the user.

4) There is a severe shortfall in the number of systems analysts and this affects the routes of entry and the types of qualifications and training programmes offered. I found a general consensus that traditional routes of entry into systems analysis through programming were inappropriate, costly and produced the wrong sort of analysts. Business and communication skills, along with organisational understanding, were high on the list of systems managers' criteria when recruiting analysts. Yet existing education and training programmes, with

their heavy emphasis on technical subject matter and programming, largely fail to meet this demand. Indeed many senior analysts and systems managers were highly critical of undergraduate training programmes, arguing that they did not include enough social sciences material and that they tended both to recruit and to produce introverts or 'techies' unsuited to the job of analyst. This was leading many systems managers to look elsewhere for systems analysts - to re-deployed end users or even school leavers who could be brought up in the culture and politics of the organisation. Further research into the type of recruitment and syllabus content which systems managers would like to see and how it could be delivered (given existing constraints in terms of time, money, accreditation, and other subject matter inclusion) would be useful.

5) Whilst organisations are buying in structured methods and the latest design tools I was surprised to find that the majority of analysts and managers I interviewed and observed seldom used them. This indicates a severe disjuncture between the advertising, literature and sales claims for such methods and the reality of practice. Most systems managers and senior analysts prided themselves on designing some of their best systems on the 'back of fag packets'. This is not mere boast on their part but is indicative of the process whereby design tends to occur - through project teams and via brain storming sessions of designers and users using pencil and paper flip charts. At best the tools and techniques available were seen by analysts and their managers as mere frameworks or signposts, or as a condensation of best systems practice; at worst they were seen as clumsy, ineffectual and problematic. There is, obviously, a range of vested

interests involved in this debate including manufacturers, vendors, and users who wish to develop their own systems. Further research into the interests of different groups involved in the design, and the sale and use of these technologies would be interesting. For example, I have already indicated the hostility with which certain analysts and managers have greeted the BCS and IEE attempts to introduce and standardise software engineering practices throughout the industry. Further research could investigate specific allegiances of interest and could detail how the industry is structuring along particular poles and perspectives.

6) None of the participatory user-centred design techniques and tools secure democratic participation of users in the design process. Indeed, design tools like CASE inhibit democratisation of the process by structuring problematics in such a way that certain scenarios are suggested to the analyst and user and others foreclosed. I would suggest that further investigation into analyst design tools and techniques would probably disclose the operation of similar design paradigms and cultures to those discussed in this thesis.

This thesis has illuminated the role of designers in the design process. In particular it has highlighted the strategic importance of systems analysts within the contemporary restructuring of manufacturing and shown how their design culture and practices enable them to define what constitutes good or bad systems design and what constitutes the organisations interest. Through the use of empirical interview and case study data it has shown that systems analysts exercise autonomy and are not merely the blind agents of capital. Rather, they actively interpret what constitutes capitals interest. Their interpretation of that interest informs the types of systems they build and consequently the quality of working life of thousands of employees using these systems.

Methods

Appendix

Philosophical Approach

Underpinning this research is what Andrew Sayer (1992) calls a realist philosophy. The principle tenets of this are that:

1) The world exists independently of our knowledge of it.

2) Our knowledge of the world is fallible. Nevertheless knowledge is not immune to empirical check.

3) Knowledge develops neither wholly continuously, nor wholly discontinuously.

4) There is necessity in the world: objects, natural or social, have particular causal powers or ways of acting and particular susceptibilities.

5) The world is differentiated and stratified, consisting not only of events but objects, including structures, which have powers and liabilities capable of generating events. These structures may be present even where, as in the social world and much of the natural world, they do not generate regular patterns of events.

6) Social phenomena such as actions, texts and institutions are concept dependant which require explanation of their production and material effects. Although they are interpreted from the researchers own frame of reference, by and large they exist regardless of researchers interpretations of them.

7) Science or the production of any other kind of knowledge is a social practice.

8) Social science must be critical of its object if it is to explain and understand social phenomena.

Social scientists invariably are confronted with situations in which many things are going on at once, and they lack the possibility open to many natural scientists of isolating out particular processes in experiments. The task of assessing the nature of each of the constituent processes within social research without being able to isolate them experimentally throws a huge burden onto the process of abstraction - which is largely ignored, downplayed or taken for granted in most texts on methods. This process of abstraction however, is central to the development of research and to the presentation of findings. Many of the debates on the relative merits of different methodological approaches (for example positivist and anti positivist[1] and in particular the dominance of 'scientism' and 'scientific method' within the research literature)[2] fail to give due accord to the role of the researcher and the process of abstraction he or she brings to bear in making sense of social actions in the research setting and in presenting research findings.

Realist philosophy has the merit of both recognising the reflexive nature of the research activity and giving due accord to the dialectical relationship between theory and practice in determining processes of abstraction and presentation of findings. Realism is therefore not a substantive social theory but, rather, a philosophy which enables the examination of substantive social theories.

The type of qualitative, reflexive, social research, which I have undertaken here is often contrasted with a conception of 'science' as empirical, systematic, rigorous and self critical[3]. However, this conceptualisation of 'value free' scientific inquiry has itself come under increasing criticism as:

> a crisis of confidence in which relativism and doubts about the possibility of empirical evaluation and scientific progress have been rife (Sayer 1992:8)[4].

My research begins from the premise that knowledge cannot be gained purely through contemplation or observation. Concepts of truth and falsity that arise through such analysis in social research are incoherent. The production of knowledge is a social activity and needs to be evaluated in terms of its practicality.

Labour is central to this evaluation and to an understanding of human development and change. It is the missing link that

> bridges the gap between knowledge and the world - a gap which has been widened both by the intellectualist prejudice and the real separation of work and living of capitalism (Sayer 1992:18).

The process of 'knowing' in this context comes not through passively observing the world as if it were external to us but from the results of material activity as 'one of natures forces operating within nature' (Sayer 1992:18). The question of truth in social research is thus not a question of theory but a practical question:

> In practice man must prove the truth i.e. the reality and power......of his thinking (Marx 1974:121).

The test of theory is its practical applicability and its utilisation in discourse to support or negate argument.

Methodology

> philosophy and methodology do not stand above the substantive sciences but serve as underlabourer and occasional midwife to them.....method is also a practical matter. Methods must be appropriate to the nature of the object we study and the purpose and expectations of our inquiry, though the relationships between them are sometimes slack rather than tight (Sayer 1992: 3-4).

At the outset I felt that a mixture of fieldwork observation and cross sectoral interviewing would provide the richest data. This approach would enable me to interact with the research setting, to build up a qualitative picture; and would enable the process of fine tuning my inquiry in the light of data I had gathered. Initially I was concerned that detailed field work studies would generate only restricted findings, but these fears were (to some extent) offset by the cross sectoral nature of the research and by its sheer scale and time duration[5]. I was also concerned about the impact of my own theoretical predilections and presence on the research context. However, as Hammersley and Atkinson (1983) argue, once one recognises the reflexive nature of social research one soon realises the futility of trying to eliminate either the researcher or the researcher's theoretical predilections from the study. In effect:

> all social research takes the form of participant observation, it involves participating in the social world, in whatever role, and reflecting on the products of that participation. Irrespective of the method employed it is not fundamentally different from other forms of practical activity (1983:16).

With hindsight, working within a labour-process perspective facilitated me in developing the research in two ways: through giving me a good understanding of the market and broader processes of restructuring; and in enabling me to assess which firms were most likely to be at the forefront of change and which personnel were most likely to be involved in this process. Likewise, it facilitated me in developing a critical interpretation of my own role in eliciting responses from interviewees and in interpreting their responses to questions. Without these insights my capacity to extract qualitative data from interviewees and from field observations would have been more limited. For example, in many instances, I was able to anticipate informants responses and fears and to take account of these in my questioning.

Designing the Research

Giddens argues that:

> All research starts from a research problem. This may sometimes be mainly an area of factual ignorance; we may simply wish to improve our knowledge about certain institutions, social processes or cultures......The best sociological research, however, starts from problems which are also puzzles. A puzzle is not just a lack of information, but a gap in our understanding. A large part of the skill of producing worthwhile sociological research consists in correctly identifying puzzles [and trying] to contribute to our understanding of why events happen as they do, rather than simply accepting them at their face value (1989: 660).

Writing from within a labour process perspective and recognising the ways in which technologies are socially shaped I wanted to find out who was involved in the design of IT systems, how they went about designing systems, why they designed the systems they did, and the autonomy they had within the design process.

From the outset I recognised that the use of questionnaires was inappropriate for the kind of cross sectoral and qualitative analysis I was looking for, for several reasons:

First, fieldwork has the merit of being more flexible. It allows the testing of ideas on practitioners in the field and the modifying of hypotheses accordingly. One does not even need a coherent hypothesis before engaging in fieldwork since the reflexive nature of fieldwork itself generates its own rich and colourful picture. Informants can speak for themselves. My research developed in this reflexive manner as both ideas and data gleaned from interviewing one group of people, for example, trade union officials, triggered off new issues, new questions and new ideas which could then be used on another group, for example, management.

Second, much of the research was in areas highly confidential, personal and sensitive. For example, I was conscious from preliminary discussions with union officers, managers and analysts that questionnaires were likely to alienate many potential informants as well as prejudicing the quality of data informants may provide. I felt that by being present and participating in conversation with informants that I would be able to elicit far more sophisticated responses from them

- by clarifying issues, picking up on possible topics of mutual interest or issues which I had not considered, pursuing possible leads and contacts and generally putting informants at ease regarding the nature of my investigations and in assuring confidentiality and establishing trust.

Third, from my own work experiences I felt that I could not fully experience a work culture merely through reading about it or receiving completed questionnaires on it. There is no substitute for being physically present. This allows one to act on your environment, for example, making personal contacts, friendships, and assimilating a wider sensory experience (for example, building up a mental picture of the formal layouts of offices, relationship of designers to others in the department and organisation at large, even the clothes they wear or their attitudes to others or yourself). It also enables more reflexivity in questioning, thereby enabling a richer appreciation of an informant's world.

Fourth, by being physically present, informants could question me! This is important to qualitative data building. It is also a daunting experience and one which many researchers may rather not face. I found that the most detailed, personal, colourful and useful information I got was from people that I had built up a rapport with over time. The problem with this approach is the need for a certain confidence and possibly 'thick headedness' but, more importantly, the capacity to immerse oneself in the informants world and culture without 'going native'. One of the most stressful, time consuming, and initially daunting aspects of this research was coming to grips with new subject matter - computing, systems analysis and design and a wide spectrum of engineering, educational, training and managerial literature. There was nothing worse than being with a respondent and not having a clue what they are talking about. I found that, once informants recognised that I had made an effort to understand their subject matter, work and culture, they rewarded me with very personal, detailed information and friendship which yielded data.

Because of the cross sectoral nature of the research (finance, services, manufacturing etc.) and the diverse groups of people I was interviewing, I recognised the need to develop an approach which would accelerate my learning curve in a host of distinct disciplines that I had little or no prior familiarisation with. Consequently, I set out to elicit the cultural knowledge of engineers and systems analysts in terms of both the tools and techniques they deploy and their values, their methods and their accounts of their own labour. I investigated this culture within a model which highlights the social interaction of groups within the design process - designers, users and managers and trade unions. Where relevant I have cited informants' verbatim and let them tell their own story. This is not simply a question of 'fairness' but is intrinsic to the reflexive nature of the whole enterprise; they tell their story in relation to my questions and assessment of the issues and problems that emerged from particular statements that they or I made. Finally, although I worked within an explicit theoretical model I did not force that model on the analysis. This is crucial because I was conscious of my own ignorance of much of my informants' work and experience and I needed to let them speak for themselves and to learn as much as I could about their world. In so doing I did not lose sight of the major theoretical issues that structured the research problematic; rather, this problematic encouraged reflexivity within the fieldwork with this, in turn, enriching my broader theoretical model.

Chronology Of Research

The research took place between October 1988 and February 1995[6]. This extended time span enabled me to develop extensive contacts, conduct many interviews and pursue a cross sectoral study; the time span allowed me to develop a perspective that otherwise might not have been possible. Much of the research after 1991 was tied in to my teaching on the engineering, computer science and social science degree courses at Napier University.

At the start of the research, in October 1988, I focused on industrial relations issues and the literature relating to business restructuring. I interviewed national and regional trade union officers for two main reasons: to build up a picture of trade union involvement in the design process and their assessment of the changes taking place within manufacturing ; and because trade unions were initially more receptive than management to being interviewed. They acted as useful `gatekeepers', who, through their strategic position and experience, helped me to establish a number of contacts with senior management in both private and public sector organisations.

During the first year of the research I carried out extensive interviews with trade union officials and shop stewards, predominantly in South Wales. Following this I secured access to a variety of organisations predominantly within South Wales but also a few in the South West and elsewhere in England.

The next phase of the research focused upon establishing contacts with systems analysts and systems managers and immersing myself more fully in the computing and systems literature. To this effect I buried myself in the computer and systems design literature. Initially I found this daunting. At the same time many of the trade union officers and managers I had interviewed directed me to interesting organisations with interesting practices and helped me arrange interviews with systems managers, analysts and programmers in a range of organisations that I thought would be of strategic value in terms of either their product structure or process. This led to the production of several working papers on the education and training of systems analysts, on the tools and techniques of systems analysis, and on their professional status. Interviewing and subsequent fieldwork of systems analysts has run through the life cycle of the research (and, indeed, is still on-going). This has been facilitated by my move to Scotland to take up a lecturing post in sociology. My work with staff and students on the BSc Mechanical Engineering and BSc

Computer Science degrees at Napier not only gave me new local contacts but opened up new issues.

Whilst engineers were a group that I was researching in Wales, I focused with renewed vigour on this group in 1992-3 as it became increasingly apparent that much of the systems analyst discourse and tool kit borrowed very heavily on engineering. Engineers constitute a distinct group in their own right, standing at the forefront of technological change and the restructuring of manufacturing, so my analysis of engineers was central to developing an understanding of the design process.

From the outset of the research I was interested in exploring issues of class and how these may have an impact upon the design process. This interest was accommodated in earlier interviewing of systems analysts and engineers. From 1992 it became a prime focus of my questioning - partly because I had had more time to ponder the issues but also because I had been gathering provocative material from my fieldwork which caused me some consternation and much contemplation. For example, many engineers and analysts sense of frustration with particular characterisations of their class position; or data which indicated that their class experiences were, in fact, influencing their exercise of autonomy within the design process.

Rationale for Fieldwork Approach

Large scale research can lend itself to a number of methods, e.g., questionnaire surveys, structured and semi-structured interviews, fieldwork or even case study approaches. Neither category need be mutually exclusive, much will depend upon the research problematic, timescale and resources and staff at ones disposal. There are a number of reasons why I chose to adopt an extensive fieldwork approach combining both semi-structured interviews and field observations[7]:

1) I was not examining one group of employees but many i.e. managers, engineers, consultants, trade unionists and systems analysts; moreover, I was concerned with addressing a number of broad issues relating to organisational restructuring, autonomy, design, democracy and social class - the accommodation of which would be less satisfactory within a traditional case study approach because of the sheer number of groups, sectors and organisations involved and the difficulty of finding an organisation or organisation with all groups present. More importantly, whilst a detailed case study has the merit of documenting in detail the specific culture of a particular group of workers within a given sector it does not readily allow one to generalise ones findings about similar groups of workers in other sectors. Yet as my research developed it was precisely these general themes, commonalties, shared lineage's and trajectories that threw light on the phenomenon which interested me. Exposure to a wide and diverse group of practising designers accelerated my

knowledge and learning curve and was responsible for my early recognition of some of the broader themes that emerged within the research.

2) Systems analysts were a largely uncharted group of workers. There was a dearth of sociological literature on systems analysts and particularly relating to their exercise of autonomy, values, culture and methods. Consequently, I needed an approach which exposed me to as wide a number of practising systems analysts as possible to develop an understanding of their work and the issues arising therefrom. A more detailed ethnography of say one or two groups of analysts in a particular industry or sector would have run the risk of going totally 'native' through having insufficient experience and information of analysts, their work, tools or techniques. In effect my objectivity could have been compromised. Furthermore, the richness of analysts' work, its diversity, the complexity of issues to emerge, would have been compromised. For example, early on in the research it became evident that a wide variety of people practised systems analysis who were not, accurately speaking, systems analysts, these were located in a diversity of organisations across a range of sectors. If I had not taken the trouble to arrange extensive preliminary interviews I may have ended up studying a group that were not at all representative of analysts at large.

3) Initial interviewing of trade union officers, management and management consultants in an attempt to gauge the depth of business restructuring and the use of

IT within this process indicated the need to capture the diversity of analysts experience and the diversity of locales in which they worked. Utilising a reflexive fieldwork approach enabled me to tackle the issues of business restructuring and the role of engineers, trade unions, and systems analysts more easily than a traditional case study approach would have allowed. For example, I may have ended up studying a group of analysts not engaged in any active projects or in an organisation that was not implementing any significant IT strategy, or in an organisation in which management were obstructive, or one in which I was not allowed access to users or trade union officers, etc. In contrast by adopting the fieldwork approach I did I could compensate for the shortcomings in any one particular organisation by picking up on those shortcomings in others. For example, one company would not let me speak to users of the system, but to offset this I could speak to users at other companies. This process could be and was applied across a whole range of issues and problems and again was possible only because of the extent and detail of my fieldwork practice.

4) Importantly, as the research progressed, fieldwork data and ideas did not develop in a smooth or progressive fashion. For example, I may have spent weeks discussing the issue of de-skilling with one group of analysts in the banking sector and let the subject lay dormant only to find several weeks or months later that another group of analysts in engineering or retail had something different to say. A more traditional case study would not have been able to build up such a detailed or rich picture of

analysts work - the model I would have had would have been more one dimensional i.e. organisation/sector specific. In contrast, the extensive and detailed fieldwork approach I took enabled me to build up a rich picture of not only analysts but also engineers work. The richness stems precisely from the diversity of individuals, organisations and sectors I studied and from my ability to cross reference and triangulate opinion and argument. For example, I could contrast the arguments of one group of systems analysts discussing autonomy in one organisation with those discussing it in another, and I could then bring in the perspectives of other groups within that, or other, organisations i.e. systems managers, engineers, management, trade unions etc.

5) Choice of a fieldwork approach which combined in depth interviewing, observation and participant observation suited both my predilection and the broader theoretical and philosophical model I was working within. I was concerned with unpacking a complex puzzle. I wanted to know the answers to many questions, for example, who were systems analysts, what did they do, what autonomy did they exercise in work and over the design process, how did they conceptualise their labour, what was their relationship to others within the design process, were they `agents of capital' automatically delivering technologies of control and deskilling or did they interpret capitals interest via a distinctive culture which could also be a site of resistance to that interest. To answer these questions and, importantly, others relating to business restructuring, design and democracy I also need to examine

management and trade union involvement in design. Once the research began I quickly recognised that even this group was not large enough and that unless I started looking at engineers there was going to be a big hole in my understanding of analysts practice. Certainly I did not feel that I could accommodate all these groups and interests within a traditional case study approach.

Importantly the fieldwork approach I took necessitated a huge process of abstraction in order to be able to assimilate, process and draw out the key themes and issues of the puzzle. This type of fieldwork involves handling large and diverse quantities of data and being able to draw out that which is significant and that which is peripheral. The gathering and grouping of observations on a large scale piece of research like this is a matter of intense debate (Glaser & Strauss 1964, Giddens 1979, Mattick 1986, Hakim 1987). For one thing the role of the researcher in setting the theoretical agenda, in being prepared to modify theory in light of field practice, and in interpreting data cannot be overstated. As the research developed I would formally group observations under discreet headings i.e. de-skilling, autonomy, design purity, etc. however, it took several months for me to establish some headings and several years for others. This was due to the way in which themes and ideas were gathered, processed, updated and modified in the light of field practice. In a very real sense, like all researchers, I was often dependent on factors outside my control, for example factors relating to access, meetings, emergence of new information, new ideas, etc. My fieldwork developed incrementally and in spurts as new data even from old informants was coming in daily and as I fed back preliminary analysis to key informants for their response. Consequently, the grouping of observations on a case for case basis was difficult.

Whilst it would have been interesting to have formally grouped observations in a series of cases and compared them that would necessitate another project. Given the time constraints and resources at my disposal it was logistically impossible. More importantly nor would it have had any practical benefit because of the diversity of personnel interviewed and observed and the diversity of organisations they were located within. I would have ended up having to group observations of some 300 personnel in some 60 organisations. The fieldwork just did not unfold in this neat fashion it simply was not the case that I had 2 or 3 companies that I could meaningfully compare. In some instances research was still ongoing in companies up until the point of write up, in others only one or two personnel may have been interviewed, in others maybe thirty or forty, in some organisations I had been interviewing trade union officials, in others managers, in yet others engineers, in yet others all three plus systems analysts! In effect I was not in a position to compare like with like. This was aggravated by the fact that in some organisations I was allowed limited observation, others none, and in some active participation in work events. Consequently to attempt to build this thesis on the basis of grouped observations in distinctive locales would have dramatically slowed down the fieldwork process and left me with insufficient time to focus on the personnel and ideas critical to my analysis. In a smaller study, one involving a detailed ethnography of maybe one or two groups of workers within a company a comparative assessment of such groupings would have been easier and worthwhile.

The fact that I was doing fieldwork in a wide variety of organisations involving hundreds of personnel and in which factors such as availability of staff, types of projects worked upon and a whole host of sectoral influences like industrial relations climate, different organisational cultures, project team participation, etc. were variable meant that it was not easy to advance concrete hypothesis on the basis of clearly grouped observations until late in the research. For example, only after sifting through several years of fieldwork did I feel confident enough to discuss the issue of democracy and the project team because that's how long it took me to formalise and make sense of the contradictory information and observations I had been witnessing from analysts and users over the issue of servant and served and user orientated computing. If I had not adopted the fieldwork approach I did then those issues may never have emerged. For example, if I had done a smaller but more detailed case study of a particular group of analysts and users I may have concluded on the basis of that one study that there was no ambiguity about the term user or that no discord or antagonism of interest was felt by users or analysts. However, through interviewing hundreds of analysts, designers and users as well as participating in a number of project teams I was able to build up a more detailed picture of the issues and recognise sites of antagonism and manipulation.

Once the process of interviewing and observing respondents had begun I could begin cross referring accounts and focusing my research more fully. In effect as the research developed key themes and issues emerged and were tested in the light of a diverse field practice. These themes and issues emerged on the basis of grouping observations under `general theme' headings, for example, de-skilling, autonomy, democracy and design, or project team practice etc. Under these headings I would note the respondents name, position, age, organisation, sector, etc. These files would then be accessed towards the end of the research when I began to focus on those themes that consistently recurred and could be discussed under general theme headings. Importantly, these general themes are personnel and sector specific i.e. each engineer or analysts might cite an example of design purity on the basis of his or her own personal experience, but because of the frequency of their expression serve to constitute a distinctive design culture which helps us to make sense of the work of engineers and analysts and which enables engineers and analysts to make sense of their own work and their relationship to the design process and others engaged in that process.

The fieldwork approach I have taken is neither superior nor inferior to that of more traditional ethnography's. Each has their own place and purpose within sociological research. The fact that I chose the former approach stems from the breadth of the research remit: examining organisational restructuring and the role of designers within that process, the consequent diversity of groups I had to study, and the need to resolve a number of important theoretical debates, for example, relating to de-skilling, autonomy, design and democracy. Whilst this kind of large scale and in-depth fieldwork can produce huge quantities of raw data it is easy for that data to get lost - a case of not seeing the wood for the trees - which is why those undertaking such research need not only a reflexive methodology but a relatively coherent dynamic theoretical model which enables them to make sense of the data and maintain the focus of the research.

Interviewees and Interview Schedules

Five key groups were interviewed:

trade union officers and shop stewards;

senior management;

systems management and systems analysts;

engineers; and

consultants.

These groups were selected because they stand in a key position in relation to information technology and the processes of business restructuring. They represent a broad social spectrum from the most senior managers to shop floor workers. I wanted to capture the diversity, range and perception of change that these different groups experienced to build up a more informed picture of the issues and processes involved and, specifically, to understand the role of systems analysts within the design process.

I approached the issue of interviewing through drawing up preliminary interview checklists. These checklists are not exhaustive.[8] In the tradition of semi-structured interviews they provided a framework. Some interviewees wished to see a copy of the checklist before they granted interviews. Because of this I was careful what to include and what to leave out of the checklist. If I felt that some topics were likely to antagonise or alienate potential interviewees then I would exclude them from the initial checklist and possibly raise them at a later date when I had won the interviewees confidence. I had to recognise the need to be realistic in winning over respondents - particularly senior management on whose goodwill and patience I was often reliant.

When arranging and conducting interviews I was aware from prior work experience and my sociological background of the differential power of my interviewees and myself. This was particularly so for some of the more senior managers I interviewed. This affected the interview and my data gathering in a variety of ways. For example, senior managers would inform me they could spare only a few minutes, or they would use their position of authority to pressure me into accepting their viewpoint as fact. On other occasions they would obstruct a particular line of questioning, or, where interviews took place with several people at once, make clear their approbation or dislike of a particular informants response or line of argument. Ironically, however, I rarely felt disturbed or threatened by this kind of posturing; generally I found it highly informative and even quite amusing. Whilst I showed appropriate deference and respect to some of my interviewees this did not stop me eliciting valuable data from them. Some interviewees clearly wielded considerable power but I in turn could be Machiavellian in my line of questioning and pursuit of data. Indeed some of the most obnoxious, arrogant and bull-nosed interviewees provided the richest sources of data. Most interviewees and informants treated me with courtesy. There was a degree of mutual respect for each other's work. Often interviewees' curiosity and awe at the task I had set myself tended to melt formal barriers and to produce a culture of co-operation and friendliness. Interviewees and fieldwork participants were often as enthusiastic about my work and findings as I was and were flattered that I found them so interesting. Obviously, this facilitated the data gathering process.

Whilst the checklist proved a useful way of securing data I was conscious of its limitations. For example it cannot easily capture the mood or culture of a particular work group or setting. This could only be captured through fieldwork. As the research developed and I became more conversant with different work groups and their cultures and practices, I relied less on checklists. Informants did not always argue logically, in fact they seldom did; themes and issues were brought up anecdotally in passing conversations, or as part of a wider discourse on an altogether different subject. Once I had established a rapport with informants and they felt comfortable enough to divulge information to me the checklists served more as a referral point, for me to make sure that key issues were covered.

The construction of the checklists was itself a reflexive process taking into account suggestions from informants. I started out with a preliminary set of questions gleaned form literature reviews and initial interviews. These were then either extended, abandoned or modified in the light of field practice and my own intellectual development. As the research progressed I found I was more readily able to target key informants with specific questions. Rather than going through the entire checklist I became more and more selective focusing on particular issues and topics that needed greater clarification.

Each checklist was designed to elicit data on the issues that were of interest to me. The five checklists reinforce one another and were designed to allow cross referencing of information and validation of responses from different groups - for example, documenting management's interpretations of change and contrasting these with, for example, the interpretations of union officials or systems analysts.

Conduct of Interviews and Field Work

Interview length varied according to a number of criteria - who the interviewee was, whether or not it was a first interview; the interviewees agenda for that day, the topics to be discussed, etc. Some interviews would be `one off' in the sense that it was made clear to me in advance that a particular interviewee would only be available for a fixed period of time. By contrast I arranged with other informants to interview them several times over several months. In some cases this was because a particular project life cycle they were working on had to unfold before I could discuss key issues and themes as they emerged; in other cases interviewees had extended the invitation to revisit them to discuss in more detail specific issues that arose in previous meetings. Some interviewees were also gatekeepers who I had arranged to keep in touch with for purposes of conveying ideas, making progress updates and establishing further contacts. Interviews varied in length from around one hour to several hours. Two to three hour interviews were common.

It was usually suggested by prospective informants that I met for a preliminary interview at their place of work during which I discussed the details of my research and the possible ways in which they may be able to assist. These initial meetings were important in that I was often given a tour of the organisation and introduced to other key personnel whom my informant thought might be helpful. From these initial meetings I could build up my contacts and arrange further preliminary interviews or studies of particular individuals or groups.

Prior to interviews I would always try to ensure that I had read about a particular company and its product or service. Likewise, I would try and learn as much as I could about the job of the particular informant I was questioning. Unsurprisingly, I found that if informants recognised I had at least made this much effort then they would generally respond positively.

At interviews I tried to adopt the customary manner and attitudes of the group I was studying. This is a question of respecting the customs and tradition of the particular group under study.

I was conscious of the fact that many interviewees might feel threatened by the disclosure of information they had passed on to me. Consequently, and as a matter of practice, letters ensuring confidentiality and details of the research were always sent out in advance of any initial meeting.

My interview settings were important. I found that often interviewees would divulge more once they were outside their place of work. Initial contacts usually took place at the interviewees place of work, but I would often try and persuade them to meet at a more 'neutral site' in the early stages of contact. I found pubs and clubs ideal places in which to relax the informant.

I worked hard at trying to empathise with informants. I would listen to their stories, however stimulating, bigoted or prejudiced, and tried not to impose either my opinion on them or to correct them. This was difficult at times, because on many occasions I had to sit and listen to offensive attitudes, but I was conscious of the fact that it was necessary to let them tell their own story; this was the best way to capture their work and world views and the nuances of their culture and beliefs.

I used a variety of data recording techniques during interviews. These ranged from tape recording the informant, personal note taking, or, on occasions, having an assistant take notes with me whilst I kept a discussion flowing.[9] I was careful not to offend an informant by utilising a technique which I felt was likely to alienate them. For example, when interviewing, I found that the use of a tape recorder inhibited some informants from divulging personal accounts to me but on the other hand helped to focus them when it came to addressing less sensitive issues. This was brought home in an interview I had with one systems manager early on in the research. He would ask me every 10 minutes 'is the tape still on' and 'I hope it got that point'. Some would become paranoid about talking with a tape recorder present. Others would ramble into the tape recorder in monotone fashion and then get angry with their own lack of panache and demand that the tape was turned off so they could `get down to the real issues'. Likewise sitting with a notepad on my knee in either an office or pub whilst at the same time trying to maintain a discussion could be tricky. I had to know when and when not to write and I found it helps to be histrionic in the process. For example, an informant touches upon an important topic and you announce `brilliant', this can lift their spirits; they can get even higher when you then move to the edge of the chair and then ask them to repeat the point so you can write it down because `its so interesting'. At the same time I was conscious not to prejudice informants responses by imposing my own particular views upon them. It is one thing encouraging informants to speak but I had to be careful not to lead them down a particular path and thereby prejudice the information they gave.

The quality of the data I was able to gather depended to a large extent on my informants' goodwill. It was essential not to compromise this through displaying inappropriate behaviour or making mindless statements which may offend. I was also conscious of the need to protect my informants. For example, in one company a senior manager from another department asked me a series of very personal and leading questions about one of my informants. I could sense he was fishing for information which he could use to his advantage and to the disadvantage of the systems manager I was working alongside. I could easily have provided this manager with the information and in that respect furthered my own access to higher managerial positions within the company, but I chose not to. This is not a moral issue, but a sound fieldwork principle. If the systems manager had learned that I had betrayed his confidence not only would he be offended but my entire fieldwork at that organisation could have collapsed. Given the reflexive nature of this kind of fieldwork I realised the role of the researcher in stabilising or undermining relationships in the cultures I was studying and the nature of my own presence and attitude on the setting.

In carrying out fieldwork in which I was granted relatively unrestricted access to a particular culture it was important not to upset the daily routines of that culture. I had to be aware that people modify their behaviour when they know they are being studied. Obviously, there were ways for me to minimise this disruption. For example, I found that having a quite senior `gatekeeper' or mentor within the organisation who would be prepared to take me under their wing gave me more credibility with others within the organisation. At the same time, others could perceive my presence and alignment with a particular individual as a threat. I had to be careful against presenting my work in particularist terms and be seen to represent either the interests of everyone within a particular culture, or my own interests. I tried to do this by spending, where possible, equal amounts of time with different organisational members, by consciously not spending too much time with, for example, the senior personnel who were sponsoring me. It also helped to be open with a wide variety of individuals in the study about the way my work was progressing and the issues emerging. For example, at the end of one day I told the systems manager that many of my interview respondents thought prototyping software was useful but within strict limits - and that it could never replace the skills of the analyst. He replied that the best way to find out was to build a mock application using me as the guinea pig. He arranged for several of the lads in the department to take me through a system the next day so that I could see, first hand, the strengths and limitations of the software.

In organising field studies I arranged, wherever possible, to discuss the nature of my research and what I was hoping to achieve with those I was about to study. This was done for a variety of reasons - to address any possible fears or distrust respondents may have; to give those I was studying the chance to ask questions, validate my findings and get involved in the research. I tried to get to know those I was observing well. Usually people responded in kind and were co-operative - sometimes forgetting I was even there.

Potentially delicate and stressful moments arose when I was invited to participate in particular discussions. These could involve a variety of forms of participation from sitting down with analysts and users with both parties asking my views on a particular system strategy or it could involve being asked to comment on any topic from politics to religion and sex at any moment and with any group or individual. I had to be extremely careful to read the moment and understand the personalities present so as not to make statements which may be seen as partial or prejudiced.

Where I felt ignorant on a particular topic or issue I declared ignorance rather than risk ridicule or antagonising a particular person. On occasions I was bailed out from awkward and politically volatile questions by people in the group who had befriended me or who recognised the inappropriateness of a particular line of questioning. On the whole, however, because I think I was seen to be interested in their work and prepared to learn: informants were generally prepared to be gracious in their treatment of me. For example, one particular software engineer invited me to use a `Quickbuild' package on his CAD machine to demonstrate one potential design scenario that he and colleagues were considering. He assumed that I could use this package when in fact I could not. I could see the disappointment on his face. My only response was to play up on my technical ignorance. This brought his laughter and his renewed determination to show me how the package worked. Throughout the fieldwork and particularly when it came to participating in discussions or using the tools and techniques of those I was studying I had to learn to walk this kind of tightrope.

Recording and Analysing Data

At the end of each day I would attempt to write up as much as possible of the relevant findings of that day. Often, it just was not possible to transcribe hours of tape recorded interviews. The way in which I collated data also depended on the means which I had used to gather it that particular day, who the informant was and where they were when I was gathering the information. For example, walking down a noisy production line where you can barely capture the odd phrase a production engineer is uttering is not conducive to the use of a tape recorder nor is it much use trying to scribble down what is said on a notepad as you walk speedily down the line. Rather, I had to retain as much as possible in my head and at the first opportunity, for example, at lunch or between meetings, jot down the key points of the dialogue and other information that may be of use such as type of products built or layout of the line.

Over the duration of my research I ended up with a variety of data from interviewees. These ranged from tape recorded interviews to extensive notes, glossy brochures and material given to me by informants to explain particular argument or process. On occasion I telephoned informants after a visit and asked them to clarify points they made in the day that I was unsure about.

As the months progressed I was building up a map of how the thesis may take shape and how empirical data could be used to substantiate, criticise or modify particular theoretical arguments. Key themes, arguments and debates would be entered into my filing system as I ordered work along several different fronts roughly corresponding to the key areas of my investigation. These were:

systems analysts i.e. tools, techniques and methods.
engineers i.e. tools, techniques and methods
the division of labour in both computing and engineering

social class
organisational culture and change
trade unions, new technology and industrial relations
users and systems design
democracy and design
management, manufacturing and restructuring

These files were drawn on towards the end of my research as I pulled together the central themes and debates and tied them into the structure of my thesis. In this process I tried to maintain a balance within each chapter between empirically generated accounts of events and change and the more theoretical accounts discussed in the literature.

The process by which key themes and debates emerged from the raw data I had gathered was complex. As the research was progressing I noted the key areas of interest and key themes emerging. In this sense I was *actively* selecting certain data that was of interest to me. However, I sought not to force the data to fit my theoretical model. Nor could I, because this model was itself developing in tandem with the data gathering and the continual assessment and reassessment of issues and themes emerging. For example, I did not advance the proposition that engineers had a notion of design purity on the basis of only one or two anecdotal comments from engineers or on the basis of the literature I had read. Rather, this perspective was selected solely because it recurred in discussion with numerous engineers and thus caused me theoretical consternation. Such consternation would push me to cross check and cross reference particular perspectives before I would develop hypotheses on them. For example, a systems analyst might advance a particular perspective on design. I could then cross refer, or triangulate, that perspective with those given to me by the analysts manager, or by other analysts, or users, or against available literature to check its durability, commonality etc.

It was not a question of my data merely corroborating my theoretical predilections. Although I was working within a labour process perspective I did not have any ready made thesis or model which served to select or distort my data gathering endeavours. Rather, I was all too aware of my ignorance of the group and culture being studied and consequently saw a reflexive fieldwork approach as the best way to elicit data and develop my own theoretical understanding. This understanding developed as a consequence of fieldwork and not separate from it. For example, initial comments by engineers on control prompted me to research a body of theoretical writing on control theory. In turn this enabled me to comprehend engineers' earlier statements and triggered further enquiry into systems theory.

The data I gathered often forced me to revise and question previous assumptions and models. For example the theoretical debates on class with which I was familiar seemed increasingly sterile in the light of my fieldwork and engineers' and analysts' practices. It was because I was conscious of these disjunction's between theory and practice that I resisted attempts to strightjacket the data into inflexible theoretical models. Where possible I used the data to critically inform and question these models.

Sources of Data

The richest sources of data relating to design, tools, techniques and engineers' and analysts' practice came from those I interviewed and observed. The data they supplied continually served as a referral point, opening up new issues or confirming or contradicting opinions voiced in either the academic or trade literature. Without this primary data my understanding of debates in the literature would have progressed more slowly and would have been more circumscribed.

The data I gathered from interviewees and case studies was supported by a variety of other information sources, including:

1) Computer based networks - I found these sources provided up to date information on a variety of topics although the searches themselves tended to be broad, time consuming and invariably in need of detailed tuning before I found the specific information I was looking for.

2) Professional bodies, associations and institutes - A variety of organisations, including the British Computer Society, the National Computing Centre, the

Institute of Mechanical Engineers and UCCA, provided data both written and verbal on a variety of issues ranging from skills to training policies to social class and trade union membership. Much of this data proved useful not only in that it often presented the 'official' position of a particular body or institute but that that 'official' position could then be assessed in relation to practice as discovered in my case studies.

3) Company literature - Several companies provided quite detailed accounts of their manufacturing and business strategies indicating why they were undergoing change and the rationale behind it. This data sometimes came from head office in the form of 'glossies' and sometimes from within particular departments or sections within a company that were working on specific projects. It proved useful in that it gave me often detailed information relating to a company's history, manufacturing processes and policies which enabled me to clarify and focus my questions when interviewing in these companies.

4) Literature from informants - This was often personal or confidential, relating to specific process changes taking place within companies that my informants were engaged in. For example, systems managers would give me their own personalised agendas for change, or explain to me current or proposed systems. The strength of this data is that is was given personally by the informant. It enabled me to clarify issues with informants and discuss in a reflexive way key points of interest. It also

meant that I could have topics explained to me in a fashion that I could understand. In this way I was able to comprehend issues quicker than I could by reading a book on a particular topic by some author that I could not cross question.

5) Industry manuals and practitioners handbooks - this encompassed access to material as diverse as SSADM or LBMS structured systems analysis and design techniques, to more personalised 'best practice' manuals that either individual systems managers, chief engineers or departments in the companies I studied were generating. These texts often gave me knowledge of the issues involved in design and because I worked through a number of them page by page, issue by issue with (for example) a systems manger or analyst at my side, I was more readily able to ask questions, raise points and get issues clarified.

6) Specific software engineering tools and packages - I was given first hand experience, sitting down with a number of systems managers, analysts and engineers, of using specific design software - for example, Yourdon's Structured Systems Analysis and Design and ICLs 'Quickbuild'. This enabled me to see how problems were structured, how designers reacted with users and how the software itself imposed its own agenda on users and designers alike. Without the experience of using packages like Yourdon or a variety of prototyping software that is used by systems designers much of my research would have been sterile and anecdotal. As it

is I have seen many of the tools and techniques that analysts use in action and this has been an invaluable input into my research and the formulation of issues.

In summary, my thesis has linked empirical data with broader theoretical debates on restructuring, design and class. Through a qualitative data gathering process, involving interviews and in depth fieldwork over an extended period, I have been able to assess the strengths and weaknesses of particular theoretical models and establish a central thesis. Namely, designers exercise autonomy within the design process through their articulation of a distinctive culture and set of practices which enables them to actively interpret what constitutes good and bad design. This thesis emerged out of a reflexive fieldwork practice.

Appendix : Checklist of Questions

Preliminary checklist areas for systems analysts and systems managers:

1) Areas of work and job definition

2) Scale of systems you are or have been involved in designing

3) Typical analysis and design procedures

4) Background and training of systems analysts

5) Skills required of analyst

6) Theory and methods employed

7) Tools and techniques employed

8) Relationship with management and users

9) Consultation with workforce over design

10) Dilemmas, choices and autonomy analysts face/have

Revised checklist in light of preliminary interviewing, literature searches and participant observation:

1) Do systems analysts have specific values that influence their designs and approach to work?

2) What constitutes a good and bad design?

3) How do you define efficiency?

4) Do systems embody particular systems analyst/ systems perspectives?

5) Is analysis and design an art/political process or is it an engineering process or mixture of both?

6) Is the process of analysis and design democratic?

7) Are project teams democratic in their structure and decision taking?

8) Do you need democracy to design good systems?

9) How do you perceive analysts professionalisation and status?

10) Which social class would you say you belonged in?

11) Is class important to you?

12) Does class affect or impact in any way upon the process of analysis and design?

Checklist of questions for Information Technology consultants:

1) What is the nature of consultancy you offer and in what areas e.g. office, manufacturing, finance, retailing etc.?

2) Do different businesses/ organisations have their own specific requirements?

3) What scale of systems do you advise upon?

4) Do you have any particular system preference e.g. decentralised as opposed to centralised?

5) Who usually brings you into an organisation and what is your usual job remit?

6) How much power and autonomy do you have once you have entered an organisation?

7) Why are you brought into organisations?

8) Is it possible for systems staff to utilise structured methods or new tools and techniques to achieve the same results as you might achieve?

9) What is the stimulus behind the IT revolution?

10) Can you think of any situations where it might be preferable not to computerise current tasks or systems?

Checklist of questions for engineers:

1) Is engineering an art or science or both?

2) Are there any values or principles that influence the type of systems/products that engineers design or is engineering value free?

3) What constitutes a well engineered product/system?

4) How do you know when your design is right?

5) Are there any factors which compromise design?

6) Do engineers get due recognition in society?

7) How do you feel your status compares to that of systems analysts?

8) What is your relationship with management?

9) How do you perceive engineers professional image?

10) Do you belong to a trade union?

11) What social class would you say you belonged in?

12) Is class important to you?

13) Does class affect or impact in any way upon the process of design?

Checklist of questions for senior management:

1) Does your company have an overall IT strategy and how does it fit in with the overall company/corporate plan?

2) Has your company introduced any new technology or reorganised production and working practices recently?

3) What motivated you to introduce new technology and new working practices?

4) Why did you choose the particular technologies and strategies that you did?

5) Did you hold consultations with other interested or affected parties i.e. other firms, consultancies, research agencies, trade unions etc.?

6) Did you anticipate any difficulties in introducing these changes, for example in terms of job demarcations, skilling, employment etc.?

7) How did you handle the process of change?

8) How have these changes affected your companies success and viability?

9) Do you anticipate similar changes being introduced in other companies in the same line of business?

Checklist of questions for trade union officers:

1) What is your union policy/guidelines on new technology

- what is your evaluation of this policy

- how do you feel it relates to TUC policy

- what is your evaluation of TUC policy?

2) What size is the union nationally and regionally

- how has membership fared since 1979

- what factors do you feel account for these changes in membership?

3) How important is union activity at either shop floor, regional or national level in securing influence over the design, introduction and working of new technology?

4) How do you think your members perceive the introduction of new technology

- how as it affected skill levels

- what problems does it pose for members

- are the problems to do with the way management has introduced the technology or do they arise from the specifics of the technology itself?

5) Are you involved as a union in negotiating with employers over the design, development and introduction of new technology?

6) There has recently been a spate of literature dealing with the so called 'Japanisation' of British industry and the introduction of new working practices like quality circles, just-in-time, and multi-flexibility. Do you know of any companies that have introduced such practices and what is your assessment of them?

7) Do you feel the current Government is responding adequately to the needs of British manufacturing?

8) What do you feel about single union deals

- are they a recent phenomenon
- has their content changed over the years?

9) Do you see any connection between recent changes in working practices and the current political/economic climate?

10) What is the future direction of British trade unionism likely to be?

Notes

Chapter 1: Contemporary Restructuring of Capital

(1) Marx argues:

> The bourgeoisie cannot exist as a class without constantly revolutionising the implements of production and thereby the relations of production and with them the entire relations of society ... uninterrupted disturbance of all social conditions, everlasting agitation, distinguish the bourgeois epoch from all earlier ones. All fixed fast frozen relations with their train of ancient and venerable prejudice and opinion are swept away all new found ones become antiquated before they can even ossify ... all that is solid melts into air, all that is holy is profaned and man is at last compelled to face with sober sense his real conditions of life and relations with his kind (1986: 37).

(2) This scrutinisation of other 'economic miracles' has many historical precedents. Kasslow (1986) stresses that this present round of scrutinisation of Japanese industrial relations is not new, in the past, other economies, including the German, Swedish, American and, of course, British, served a similar purpose.

(3) As the Economist (1983) pointed out, Japan is far from being a miracle economy; rather a few 15-storey industries dominate a mass of medium, smaller sized firms and sweatshops, operating in international terms with below average productivity's of labour. Complementary to the dual nature of the economy, there exists a dual labour market, predicated on only one third of the workforce being unionised and receiving the benefits of the company world. As Briggs (1988) and Kamata (1983) point out, life-time employment and seniority wage systems can actually serve to immobilise Japanese capital, preventing management's redeployment of labour and rationalisation of production, as well as leading to huge costs of 'socialisation' which, by and large western companies are not burdened with. Furthermore, life within the 'company world' is far from being a harmonious sanctuary and is, in fact, the site of intense competition, stress and anxiety (Halliday 1975).

(4) A number of writers have pointed out the coercive nature of quality circles and the stress and humiliation Japanese workers feel when they can no longer keep up performances (Kamata 1983, Littler 1982). Japanese working relations at Komatsu's plant in N.E. England explode the myth of 'happy familyism' and highlight how quality circles and 'happy familyism' are primarily attempts to reduce poor quality and improve productivity through incorporating the workforce into a shared belief system (Hauge 1987).

(5) Hill and Blyton's (1987) argument that flexibilisation does not significantly reduce labour costs and cannot, therefore, be said to benefit British business misses the point. It is not a question of reduced wages *per se* but increased exploitation, i.e. labour productivity. Wages can rise yet the rate of exploitation rise even more dramatically through strategies of Japanisation.

(6) Teleworker cited Channel Four (1995) 'Visions of Heaven and Hell'.

(7) I found that. advances in Computer Aided Design (CAD), Computer Aided Manufacture (CAM). Computer Integrated Manufacture (CIM), Robotics, Statistical Quality Control (SQC), Line Balancing and Just in Time (JIT) techniques have enabled many of these firms to achieve product diversity. improved quality and "flexibility" whilst at the same time streamlining or abolishing supervisory and middle manager grades but still retaining hierarchical control and centralised power.

(8) In the coal mining industry Winterton (1986) has shown how MINOS and FIDO operating systems were used by the NCB to monitor machine cutting speeds. work stoppages. outputs and labour productivity's, not only on different teams on the same face, but against other teams on other faces and in other pits and regions, this data was then used by management to victimise miners before, during and after the strike.

(9) There are several Regulation Schools each has its own distinct focus:

The Grenoblais School - there are two main reference points for this school; a sustained critique of the theory of general economic equilibrium as an adequate basis for understanding the dynamic of capitalist economies (Bernis 1977, Ruzza 1981) and a periodisation of capitalism into three stages: competitive, monopoly and state monopoly capitalism, each with its own mode of regulation.

The Parisian School - initial studies were concerned with Fordism in the USA, the nature of monopoly capitalism, the causes of inflation and the development of public spending. In contrast to the Grenoblais and orthodox state monopoly capitalist theorists Parisians distinguish two basic stages of capitalism: 'extensive' and 'intensive'. In an 'extensive accumulation regime' capital expands by merely spreading into new areas of economic activity at the expense of non-capitalist producers. In an 'intensive accumulation regime' capital accumulates mainly through reorganisation and rationalisation of existing areas of activity, mechanisation and hyper-mechanisation leading to the production of relative surplus-value. The 'extensive' regime is characterised as having a competitive mode of regulation, the 'intensive' regime as having monopolistic regulations (Lipietz 1988).

The PCF-CME School - inspired by Boccara, the PCF developed a new view of state monopoly capitalism based on a law of 'over-accumulation - devalorisation' and its impact on the relations between private monopolies and the state. According to this school short term tendencies towards over-accumulation can be eliminated through the actions of private capitals as they reorganise the labour-process and/or modify the conditions in which surplus-value is realised: whilst in the long term over-accumulation must be eliminated through devalorisation of a large part of the total social capital, responsibility for such devalorisation devolves primarily to the state. This approach focuses on how monopoly capital is advantaged by state measures which transfer the formal ownership of capitals or redistribute profits among private capitals. It qualifies as a regulation approach by virtue of its economic and mechanistic analysis emphasising the changing economic and political procedures needed to regulate capital accumulation within successive stages of capitalism (Boccara 1976).

The Amsterdam School - has developed a distinctive approach based on a Marxist critique of political economy utilising Gramscian analysis of hegemonic strategies. Its key concepts comprise: 'fractions of capital' and 'comprehensive concepts of control'; the latter referring to potential hegemonic projects intended to win both bourgeois and popular support within an accumulation strategy which advances the particular interests of a dominant fraction of capital whilst also securing the needs of capital in general and providing a flow of symbolic and material rewards to a critical mass amongst the dominated classes (Jessop 1988).

The West German School - the most distinctive feature of this school is its focus on 'societalisation'. Attention is focused not only on the accumulation process considered in a narrow economic sense, but also with that of capitalist societies as a whole through specific modes of 'mass integration' and the formation of 'historic blocs' (Hirsch 1986, Lutz 1984).

The Nordic School - explicitly influenced by Parisian regulation theory, this school is distinguished by its concerns with national modes of growth and national modes of economic policy making, reflecting the mode of growth, the political traditions, and the changing balance of economic and political forces within each country (Mjoset 1985).

In addition to these six European schools regulationist currents can be discerned in America and Britain. In America the most distinctive is the so called 'social structure of accumulation' approach which argues that sustained periods of accumulation require specific social and political conditions to support and reinforce the economic factors making for growth. The social structure of accumulation being reproduced through a specific balance of forces, changes in this balance leading to possible major economic crisis (Gordon 1980). Two other regulation currents also exist in America, they comprise analysis of Fordism, neo-Fordism and post-Fordism and studies into the conditions of post-war American growth (Edwards 1982). In Britain the focus has been on 'strategic relational' accounts of the state, post-Fordism and strategies focusing on the dialectic of structure and agency (Jessop 1983).

(10) Regulationists emphasise that whether or not this system is realised, or not, is determined by contemporary struggles and not any iron laws of history which propel the masses into revolutionary struggle. Yet they nonetheless talk of new accumulation regimes as though history had already made its final pronunciation on the subject - that is their analysis is teleological.

(11) The Regulative model is an attempt to juxtapose most of the schools and debates into some kind of ensemble. The model also attempts to show an accumulation regime in its totality and the different points which can be interpreted as the crux of the regulative ensemble. It is an ideal type, thus it should be read very liberally. The direction of the arrows should not be read rigidly, in their present position they signify RTs assessment of the British debates, but some regulationists would reverse the direction of the arrows, ignore some of them or even abandon part of the model. This schematic diagram does not do full justice to RT because further detail can be built in. For example, the diagram as it stands veers towards creating the impression that one regulative system exists at one time, when in fact the regulation model can readily accept articulations between Modes of Regulation and Regimes of Accumulation, so that several forms may coexist and articulate, somewhat like the 'articulations of the modes of production' debate. In this sense RT marks an exciting extension of these debates as the permutations (theoretically at least) are endless. At a concrete level this is saying that different Modes of Regulation and Regimes of Accumulation may exist in different fields or even within the same field. Thus, for Regulationists at the height of Fordism, certain sectors, e.g. catering used pre-Fordist techniques. Likewise, Regulationists argue that as consumer goods currently move into post-Fordist systems, restaurants are just entering the Fordist system i.e. Wimpy/MacDonalds. etc., these in turn coexisting with pre-Fordist outlets, e.g. the local Chinese takeaway. Of course the difficulties then arise in determining the relative primacy of sectors and of closely measuring/isolating the types of productive technique used, something which to RTs lasting discredit they have nowhere successfully done.

(12) Department one refers to the capital goods sector of the economy - capital invested in production of the means of production: machinery, raw materials, chemicals, power, etc. Department two refers to capital invested in the production and realisation of consumer goods and services.

(13) Jessop (1988) argues that in addition to the above general problems experienced within the international Fordist Regime the UK had its own particular domestic problems which resulted in the development of "flawed Fordism". The peculiarities of the British social formation - existence of empire, strength of labour movement, domination of city institutions over industry, the peculiar gentry culture of the ruling classes, meant that Britain was achieving Fordism just when it was going out of fashion. In other words, Britain was instituting mass production plant (super-steel mills, etc.) just when its competitors were supposedly switching over to flexible production facilities (mini-mills, reprogrammable robots and flexible production lines, etc.).

(14) Attempts to drive down wages, lengthen the working day, intensify work through closer supervision, either personal or electronic, shifts to home working, short term performance related contracts, the utilisation of female and child labour, abolition of legal minimum wage, etc. are all attempts to increase absolute surplus-value production; these processes are contingent on the balance of forces, the political context and class struggle.

(15) Meegan (1988), Morgan and Sayer (1988) argue that strategies of flexibility in the UK with their focus on product differentiation usually indicate that companies are in trouble and that far from being evidence of market strength or indication of emergent regimes are actually a sign of imminent death as they usually indicate a firms exclusion from the market by those able to live in the more profitable world of high volume production. Management at one company I studied made it clear that their decision to go dedicated and to abandon strategies of niche marketing and production stemmed from the fact that equipment and labour in the plant were not being used maximally and that traditional markets were declining. Rather than continue production within a declining market base this company decided to invest heavily in dedicated, predominantly Taylorist, high volume, narrow product range manufacture, focusing on only 12 product varieties from the previous 100 plus and narrowing the customer base from over 160 variegated customers to only 25.

Chapter 2: Engineers Values and Methods and Role in the Design Process

(1) Thus, for example, many engineers, particularly in heavy engineering, conveyed to me their sense of frustration and despair over the run down of British manufacturing and lack of interesting projects, and sense of status and worth that goes with them. Alternatively, systems analysts tended to be far more optimistic about the restructuring of business, perceiving, on the whole, a key role for themselves and information technology within this process. Both groups however, were concerned over the particularities of Government strategy and more broadly what they perceived as an 'anti-productivist' culture within the UK economy. These issues are discussed more fully below and in chapter six.

(2) Thus, for example, in the light of changed terms of competition one particularly dominant design philosophy - Taylorism has come under increasing criticism from both management and engineers alike as no longer suitable to the market conditions of the 1990s. The point is that not only do engineers reassess their practice in light of changing social circumstances, but perceptions of their own role, status and relationship to others within the design process likewise undergo continual change. For example, the dramatic ending of the old seven year craft apprenticeship and the new graduate recruitment route into engineering is reputed to have had a dramatic impact on engineers relationship to shop floor workers and the development of particular engineering tools and approaches (Smith 1986, Lane 1995).

(3) For example, both systems analysts and engineers present their work and relationship to both the design process, management and the shop floor in similar vocabularies. Systems analysts

also borrow heavily from the engineers 'tool kit' - utilising systems and control theory and a whole series of underlying philosophies and attitudes towards the design and organisation of work.

(4) The specific methodological approaches and values I focus upon in this chapter are not the only ones which engineers hold. Engineers, of course, are members of society, consequently it would be surprising if the values and cultural symbols of that society did not colour their approaches to design. Vasiland (1990), for example, argues that engineers are utilitarian and that engineering practice is shot through with utilitarian philosophy. Engineers and analysts make utilitarian decisions every time they cost-benefit a design i.e. weighing up the costs of routinisation, or deskilling, against possible benefits in terms of wage savings and productivity improvements. Likewise broader patriarchal and sexist cultures have been noted amongst engineers (Cockburn 1985, Cowan Schwarz 1976, 1979, Faulkner & Arnold 1985, Wajcman, 1991). I have not been able to spend as much time exploring these particular issues as I would have liked. To give but one example, one particular engineer was showing me a number of proposed drawings for a new range of washing machine. He explained why he favoured one particular design: 'I like this design, its uncluttered, there's not a lot of idiot switches...you cannot afford complexity, its best to in-build decision making into the circuitry...no we don't want complex switches and instructions...no, these will put your average housewife right off...its best to keep it simple. You know what women are like' (Design Engineer. White Goods Manufacturer, Wales).

(5) Although one of my research intentions was to establish ways in which engineers values and methods have an impact upon the design of work and engineers own formulation of that work; the different value systems and methodologies which engineers held came about through discussion and observation of engineers at work. In effect, although my analytical position was that of labour process theory, the specific value systems of engineers emerged in the course of my immersion in the daily practices of engineers. The particular values systems and methods I have chosen to focus on are not exhaustive; they merely indicate important ways in which engineers conceptualise their activity and the way that activity can shape design practice. Further research is needed in this area and I would suggest useful cross cultural studies would be useful.

(6) Stimpson (1991) uses the second law of thermodynamics to make the point that engineers need to remember that notions of constancy are 'unscientific' and that too many engineers, in their desire to attain states of 'constancy' and 'control' are disrupting the balance of the universe.

(7) As Hales (1982) argues, a process of mathematical and operational reductionism takes place within the sciences. The mathematical reduction seeks to break down *qualities* into specifically measurable and definable *quantities* which can be worked upon, i.e. quantitative physical laws; the operational reduction seeks to pin down a *quality*, in a quantitative form, so that other experimenters may use the same unreal language to make reality stand still. long enough for objects to be singled out and have numbers stuck on them.

(8) As an operational methodology, such an approach has its weaknesses, hence the comment from the engineer above, who remarks sarcastically on hitting problems with the design of a particular surgical implement that he will just go back to ever more sophisticated calculus and utilise the computer software to construct ever more realistic scenarios of reality.

(9) Novack (1978) argues that this is easy to prove, if we observe these two letters under a lens - they are quite different from each other. But one can object, the question is not the size, or the form of the letters, since they are only symbols for equal quantities, for instance, a pound of sugar. The objection is beside the point; in reality, a pound of sugar is never equal to a pound

of sugar - a more delicate scale always discloses a difference. Again one can object: but a pound of sugar is equal to itself. Neither is this true: all bodies change uninterruptedly in size, weight, colour, etc., they are never equal to themselves. A sophist will respond that a pound of sugar is equal to itself at "any given moment". This does not withstand criticism. How should we really conceive the word moment? If it is conceived as an infinitesimal interval of time, then a pound of sugar, during that moment, is subject to inevitable changes. Or is the "moment" a purely mathematical abstraction, a zero of time? But everything exists in time; and existence itself is an uninterrupted process of transformation; time is consequently a fundamental element of existence, as was made clear to the above engineers, once the calculus was unfrozen!

(10) As Ouchi (1981) argues, MRP tells people what to do but it does not consider their psychology's, needs or interests; as such, it is an explicit rather than implicit form of control which tends to alienate workforces and sap creativity. Ploss (1990) argues that there are three basic flaws with MRP, all relate to its underlying architecture. First, forecasts are always wrong, the business environment, product quality, demand, etc. are too variable; humans, material and processes cannot respond quickly enough even if initial forecasts were right. Second, there are no quality improvements, MRP is a 'push' system of manufacturing planning and control, whereas JIT, Ploss preferred model, is said to thrive on controlling quality and improving it via mobilisation of organisational culture and people, not a piece of computer software. Finally, Ploss argues, MRP evolved from the 'scientific management' concept and is intended to make factories efficient not through mobilisation and harmonisation strategies, but through reducing manpower and human discretion, using standardisation and automation (cited Chan *et al*, 1990).

(11) These approaches share many of the characteristics of the analytic tradition, which received added impetus with the development of bourgeois society and, in particular, the need of manufacturers to specify, detail, control and predict, manufacturing processes and labour. The strongest proponent of this view, of course, is F.W. Taylor, and the Time Motion and Methods study programme he initiated (Littler 1978, Wood 1982).

(12) Taylor's book 'The Principles of Scientific Management', starts from the premise that the nature, pace and intensity of work should be organised 'scientifically' and that many existing work practices are found wanting. In particular, he asserted that if not closely supervised, labour would "soldier" or slack doing the minimum amount of work for the maximum wage. He also maintained that poor organisation of work led to 'inefficiency' arguing that both wages and profits would rise if work were planned 'scientifically'. On the basis of extensive time and motion studies, Taylor and his colleagues sought to highlight the ways in which labour productivity could be increased. The chief mechanisms for achieving this being - increasing the division of labour, separation of conception and execution of task and deskilling. The first principle is premised on successively breaking down a skilled task into a more routinised and repetitive unskilled task. Implicit in this assumption is that the person breaking down the task has a superior model of how that task should be carried out. The second principle is premised upon taking away the knowledge of skilled workers, both theoretical and esoteric, of production processes and productive technique and embodying it in the hands of designers, engineers and managers. Again, implicit in this formulation is the assumption that engineers and managers can appropriate this knowledge and will have a superior method of organising production. Finally, as a consequence of the above two processes the tasks have become so simplified and routine that management can utilise cheaper deskilled labour and more readily replace workers.

(13) Ingall (1965) has reviewed ten or so major algorithms used by production engineers. They all embody the same assumption that, on average, different operators work at the same pace throughout a shift, on average cycle time of operations is irrelevant, on average learning on

the job can be ignored, on average, variations in parts and equipment can be ignored. An average, however, is just that: it represents a mean value, it does not even tell one whether the exact average state has occurred:

> One thing for sure, on any given line at any one time you can be sure that all aspects will not be operating at their average value (Production Manger, Automotive Components Manufacturer, Wales).

(14) In discussing the shift to group working at Volvo's Kalamar car plant, Buzacotti argues:

> The revolution at Kalamar has not been throwing out the assembly line but eradicating the organisational principle of the one man, one shift, one station, a principle that had no intrinsic relation to the design of assembly lines but was, rather, a management time and motion imposed structure (1986: 837).

(15) Thus to control is to apply goal directed constraints to energy and activity. Direct control is seen as that which is affected by the structure or pre-setting of a control device whereas feedback control has three main elements:

(a) a control device affects output in the same way at any given moment that direct control would do.

(b) some characteristic of the output is measured against a standard,

(c) information about variance from standard is fed back into the process causing the control device to change its effect.

In short, feedback control is one that varies its control of output in accordance with a comparison of the output with a standard. A feedback control system can be completely mechanical, i.e. a 'closed loop system' where information is automatically fed into the system via some readout device; or an 'open loop system' necessitating human agency to act upon and modify the current system in the light of new information.

(16) Cooley (1983) relates how four PhD mathematicians, at Lucas Aerospace, had been trying for four years to design an afterburner of a large jet using mathematical equations and computer-aided design technology but could not do it; meanwhile they found that a sheet metal worker on the shop floor, together with a draughtsman, had actually succeeded in drawing and making a successful prototype of one of these afterburners.

(17) In Britain, Scott (1958), was one of the first social scientists to consider the factory as a social system, comprising three key elements - occupational structure, formal structure and informal structure. He placed great emphasis on the latter, for any understanding of the functioning of a particular organisation. The dichotomy between formal structure, as something defined, explicit, recognised and purposive and the informal structure as characterised by spontaneity, affinity and congeniality, began to feature prominently in sociological accounts of industry from the late 1950's and entered slowly into the engineering vernacular via the work of Trist (1960) and the Tavistock Institute during the War years in their analysis of bureaucracy. Roethlisberger and Dickson (1939), Scott (1958) and Blau (1956) all rejected the notion that the 'informal' structure of an organisation was 'dysfunctional'. They all sought to stress the ways in which the non-official, informal relationships and practices can assist an organisation achieve its stated goals, as well as the ways in which it may hinder that achievement. This stands, in stark contrast, to the majority of systems theory deployed in engineering today which still focuses on the 'formal' structure and seeks to impose order and control over the 'informal' - to quantify and eliminate it.

(18) This is evident not only in the small slot social science and particularly sociology and sociological studies of technology have in engineering curricula but was evident from my interviews of engineers, engineering educators and course validators. One Chief Design Engineer and Course Validator, in particular, was forthright in his condemnation of engineering degrees:

> Despite Finniston ... despite years of proven debate concerning the need to enlarge upon the social science component of engineering degrees so as to provide a more rounded adaptable engineer ... the kind that the market needs ... little has been done. Too many Heads of Department and Professors are stuck in the mud ... their view of engineering is simply out of touch with the times and out of touch with the needs of engineers themselves ... every year these individuals keep churning the same old techies of the line ... with the same abysmal understanding of business and organisation ... the same abysmal communication skills and consequently suffering the same indignities of lack of career promotion and streamlining off into technical rather than managerial grades (Chief Design Engineer. Aerospace Industry, England).

My own experience of teaching engineers shows the arrogance and contempt displayed towards the social sciences by some engineers. One particular Professor and Dean of Engineering, in a bitter exchange involving several senior staff said that he wanted a "factual business" input into his degree and not a "value loaded", "critical" sociology of technology and design. Discussion of class, controversy, and the politics of design and engineering practice was, for this Professor, too much to bear.

(19) Kevin Webster is a car mechanic in the British television series Coronation Street. In a 1991 survey conducted by Nottingham University into teenage perceptions of engineers teenagers were asked to name any famous engineers' they could think of - Kevin Webster was the most cited response (cited in Daily Record, July 6th 1991)

(20) The essence of Armstrong's argument is that, insofar as the managerial credentials of professional engineers rest upon their position of authority within productive labour, they are out of key with the conception of management, dominant in Britain. For many years, the engineering profession has tried to overcome this by adding managerial subjects to engineering education. However, so long as management is conceived of as a distinct field of study in its own right, such a strategy can do little more than place engineers in the position of amateurs competing with full time specialists.

(21) From this stereotypical classification of what constitutes management, it is but one small step to offer the same managerial courses to everyone from foremen to top executives irrespective of industrial settings. It is the same logic which also enables management consultants, like fortune tellers, to offer essentially the same service to all customers.

(22) A 1990 survey of engineering graduate employment shows that two out of three recently graduated engineers were using their degrees to get out of engineering and into areas like management and accountancy (MacKillop 1990).

(23) Armstrong argues that management is part of unproductive labour, i.e. that it is not directly productive of surplus-value but rather ensures the social relations are right for surplus-value to be produced in. For Armstrong, it is from this sphere of unproductive labour that control originates. Management becomes concerned with global decisions whilst those carrying out productive labour only become concerned with technical decisions. Wright (1976) has pointed out, many workers, i.e. office workers, bank clerks, maintenance and repair workers, dustbin

men. cleaners. etc., are also not directly productive of surplus-value. but this does not mean that they are not workers. or that they hold an anti-productivist philosophy.

(24) For example. Forty (1994) relates recent changes in design aesthetics to an abandonment of modernism on the part of designers:

> Modernism...was a unique attempt to create a system of values independent of the vagaries of fashion and taste. This system defined quality in relation to the way the object was produced....the most general complaint against modernist design has been that it has made everything look the same; it has suppressed difference....one aspect of this new modernist principle lay in eliminating ornament, and another lay in reducing the variety of products down to a few or to just one design...the icon was the Model T Ford (1994: 28-29).

Stumpf (1994), on the other hand, argues that design has become commodified and swamped under style. That there has been a 'stylisation of life' reflected in an image based throw-a-way culture. This has had the effect of inculcating in designers a preoccupation with style and a lack of focus on content and proprietorship:

> There is a difference between consumption for consumption's sake and the notion of proprietorship as it was alluded to in our Constitution....My Swiss grandfather, who lived to be 94, used only two straight razors his whole life. A man today, from age 13 to 73, can be expected to use 12,000 disposable razors. The idea of proprietorship is not to keep the traditional straight razor but is, perhaps, to design one that could be sharpened a dozen times (1994: 23).

(25) By contrast Evamey (1994) argues that some designers, particularly those designing for the upper end of the market, are moving away from the functionalist lines of modernism towards a new style reflected in the creation of products whose primary function is philosophical rather than practical but this in turn has done nothing for the image of the designer:

> The liberating influence on industrial design of post-modernism has been unmistakable: the power of the visual image of the product has been exploited by manufacturers the world over. But the result has been that the designer is reconfirmed in the minds of many in industry as a purveyor of image only, unable to be trusted with anything serious like engineering (1994: 14).

(26) For example, Ward (1990) argues that within design there is an hidden curriculum which serves to inculcate in designers a particular attitude towards design which reinforces within students an uncritical acceptance of existing authority and traditional design paradigms, which downplays enquiry and free expression and which stifles creativity and community based design concepts.

(27) The issue of 'compromise' within the design process is discussed more fully in Chapters 3 and 4. Systems designers recognise that systems are ultimately 'compromises' between different groups, value systems and interests, which, ultimately challenge dominant notions of 'efficiency' and 'technologically deterministic' accounts of design and development. More generally, the notion of compromise as a route into understanding the social construction of technology is central to a number of sociological accounts of technological development. Particularly relevant here is the work of Callon (1986) on the technological controversies surrounding the development of the electric vehicle in France; Noble's (1984) work on engineers and the development of CNC machine tools in America and Pinch and Bijker's (1984, 1990) social constructivist work on the bicycle and debates in solar physics. In each

case the authors focus on failed as well as successful technologies, exploring why one particular design becomes successful and other interpretations get dropped.

Chapter 3: Systems Analysts Work, Values, Methods and Role in the Design Process:

(1) This chapter develops and extends ideas discussed in earlier papers written by Lane (1988a 1988b) and Mackay and Lane (1989).

(2) I studied systems analysts in a wide variety of organisations with the intention of building up cross sectoral data on their work, values and methods. The objective being to more accurately capture the diversity of organisations systems analysts work in and the way in which this may affect their practice. I also wanted to be able to contrast systems analysts work experiences with those of engineers and cross sectoral analysis facilitated this.

(3) Oxman (1990) argues that one of the characterising aspects in the emergence of a theory of design methods has been the belief that logic and rational procedure are in themselves the foundation of design. The BCS and IEE in their enthusiasm to distance themselves from past design traditions based upon intuition, preferred models and practice risk alienating many potential designers and discarding a rich knowledge base which may not be readily amenable to encodement in particular methodology, tools, or technique. In this context Oxman argues that prototyping software may be one way of bridging design knowledge and design practice:

> With respect to knowledge based design systems, the use of the prototype, as a knowledge structure, provides an effective basis for the organisation of design knowledge (1990: 21).

Stolterman (1994) argues that today almost nobody questions the idea that design should be based on theoretical and scientific knowledge. This is, however, historically a quite new idea. For example, early engineering schools were established as parts of art schools. With the enlightenment however, a new picture of the engineer emerged. The engineer was now a person able, on the basis of scientific knowledge, to tell the practitioners, the artisans, how to do their work. Today the education of engineers is almost totally dominated by the idea of the superiority of theoretical knowledge over the practical knowledge obtained by doing. The BCS and IEE in their enthusiasm to establish the professional credibility of systems analysts via the stabilisation of a particular tool and design paradigm may be doing much to undermine what has been described to me by practitioners as a personal, political and artistic process, requiring characteristics like flair, business nouse, communication skills and creative thinking.

(4) Sargent (1994), for example, argues that attempts to synthesise a design science in terms of a particular set of proven methods, tools or techniques is exacerbated by the variety of design activity. Any unified design science would have to cover the following types of design activity:

Search
Exploration of emergent information
Decision making
Matching and disposition
Negotiations concerning trade offs
Optimisation
Planning
Learning
Logical deduction
Solving sets of equations
Teamwork
Constraint management

Production systems
Linguistic transformations
Problem solving
Use or construction of idioms

Sargent argues:

> the techniques and methods used by designers can be seen to be derived from practice and are not in principle derivable by any kind of design science although the elegance of their reformulation may present that appearance (1994: 391).

(5) The NCC (1984, 1994) foresees a strong and continuing role for systems analysts as information technology becomes a core business activity. Analysts with good organisational awareness and business understanding are perceived by the NCC as being in a good position to advance their own careers and it is expected that demand will rise as more complex real time systems come on line and organisations network more and more information.

(6) (6) Sargent (1994) argues that failure in design should be a central element of the learning process of designers and that any design science needs to acknowledge failure and attempt to build up a typology or culture of failure which will help enrich design practice.

(7) For example, Dovey (1990) discusses the work of Alexander and his attempt to develop a pattern language which focuses designers attention on a number of key issues. For example, what constitutes a good or bad design, debates on gigantism, puritanism, totalitarianism and ethics in design. Alexander (1979, 1985, 1987) has developed a series of patterns covering issues as diverse as house building, office design, public works and 'access to water'. Each of these patterns addresses issues of ownership, responsibility, or aesthetics etc. and indicates the issues designers face on a daily basis and their attempts to conceptualise their own design activity and raise it to a higher ethical level.

(8) For example, Evamey argues:

> Designers use a more chaotic way of reaching solutions than that of the engineer, marketer or economist, and it is the job of uniting creative and logical minds behind a common goal that worries so many businessmen (1994: 15).

Chapter 4: The Software Bottleneck

(1) According to the NCC (1984) the boundaries of an investigation are usually stated as departments, groups or functions which are to be studied or sometimes excluded from the study. If the analyst can be given a list of those people or groups who provide input to the area to be investigated, and a list of those who receive output from it, i.e. the sources and destinations, then he has, by implication, been given the boundaries. Neither 'source' nor 'destination' are to be investigated - but all areas in between are.

> Normally, the people who are the sources of input data and the people who receive output, the destinations, are outside the area to be investigated. Everyone and everything in between the sources are destinations is in the area of study. (1984: 35)

The NCC (1984) recognise this model assumes the analyst can identify precisely key data flows into and out of the area of study. The NCC also acknowledge that exploration of a source or destination may occasionally be required by an analyst. What the NCC fails to recognise, however, is that many analysts are either ill-equipped, or lacking the necessary organisational back up to do this; many preferring to accept source and destination boundaries within a system and to utilise a narrower, more comfortable definition of users - i.e. those falling *within* the pre-defined boundaries. This spares many analysts the unpleasantness, stress and additional time and effort of entering into the murkier terrain of organisational culture, power and politics.

(2) This is one reason why the NCC recognises the continuing role of the analyst arguing that much of the literature on specific methodologies, tools and techniques imply a clear cut process of analysis and design, when, in fact: 'This is never true' (1984: 172).

> The idea of change generally emanates from senior management, particular for larger projects, though in some instances it may flow from senior systems staff. The critical point is that most analysts who are part of the chosen project team will seldom question the validity of the project. One possible reason is that if they were thought to do so then they would not be chosen by senior management to be team members. Another possibility is that both the originator of the system and analyst share a similar discourse and have similar interests in seeing the system developed. Further explanation can be sought in the division of labour and the actual structuring of projects. The majority of analysts work takes place in the context of a system life cycle. This structures the actual day to day activity of analysts from fact finding through to preparation of structured specifications. Ironically, analysts working in project teams invariably work to tight budgetary and time constraints these serve to push the analyst through the various stages of the system life cycle as quickly as possible. In this context few analysts question either the individual idea or the composition of teams. In particular, user input at stages 3, 4 and 5 are critical. Analysts will often side with more senior personnel in railroading through these particular stages of the system life cycle, particularly if faced with recalcitrant or obstinate users, whose demands may be deemed 'extravagant', 'unreasonable' 'dysfunctional' or too time consuming or costly etc.

Chapter 5: Trade Unions, New Technology and Work Redesign:

(1) Thirty five trade union officers from 16 different unions were interviewed:

Union	Representation/Sector
UNISON	Health Care
TGWU	General
NALGO	Public Service
SOGAT	Publishing
NGA	Printworkers
TASS	Scientific/Engineering
AEU	Engineering/General
EEPTU	Electrical/General
USDAW	Shopworkers
MSF	Manufacturing/Scientific
AEEU	Engineering/General
CMA	Postal service
STE	Telecommunications
GMB	General
APEX	Professional and clerical staff
NUM	Mineworkers/Mining

Table 2. Unions Accessed

Note : unions are increasingly unrepresentative of particular crafts or groups of workers and this is reflected in their increasingly anachronistic titles e.g. AEU represents *all* workers at Nissan and not only engineers.

These unions were chosen because they represent members in a broad cross section of manufacturing, finance and service based industries. They enabled me to build up a model of change in the respective industries and trades their members were employed in. In addition union officials provided valuable data on union perceptions of change and union involvement in the design process. They also proved very helpful in establishing contacts for me with management and in suggesting possible companies that may be of interest to study.

(2) The majority of union publications on new technology were in the early to mid 1980s, reflecting the TUC's official endorsement of the NTA strategy towards union involvement in the design process - for example:

APEX (1985) Job Design and New Technology.
NALGO (1986) New Technology and Change - Negotiating Guidelines.
APEX (1984) Office Technology - The Trade Union Response.

Since the mid eighties union concern over issues relating to the design of technology and work has fallen sharply (McLoughlin & Clark 1994, Beaumont 1995, Hyman & Mason 1995).

(3) TUC checklist on new technology agreements:

(a) Change must be by agreement: consultation with trade unions should begin prior to the decision to purchase, and status quo provisions should operate until agreement is reached.
(b) Machinery must be developed to cope with technical change which emphasises the central importance of collective bargaining.
(c) Information relevant to decision making should be made available to union representatives prior to any decision being taken.
(d) There must be agreement on both employment and output levels within the company. Guarantees of job security, redeployment and relocation agreements must be achieved. In addition, enterprises should be committed to an expansion of output after technical change.
(e) Company retraining commitments must be stepped up, with priority for those affected by new technology. Earnings levels must be secured.
(f) The working week should be reduced to 35 hours, systematic overtime should be eliminated, and shift patterns should be altered.
(g) The benefits of new technology must be distributed. Innovation must occasion improvements in terms and conditions of service.
(h) Negotiators should seek influence over the design of equipment, and in particular should seek to control work performance measurement through the new technology.
(i) Stringent health and safety standards must be observed.
(j) Procedures for reviewing progress, and study teams on the new technology should be established (TUC 1979).

It should be noted that only checklist number eight specifically seeks to address the issue of union involvement in the actual design of equipment. The majority of the measures are designed to cushion the impact of technology on employees and to secure working conditions, living standards and adequate health and safety provision.

(4) WIRS (1990) survey evidence suggests that of the 43% of workplaces using new technology which reported a reduction in their manual workforce only 9% claimed this was due to the

adoption of microelectronic technology. More commonly cited reasons for job losses were reorganisation. lack of demand. or imposition of cash limits by central government or local authorities.

Chapter 6: Engineers and Systems Analysts: Class and Work

(1) For example. Poulantzas' (1973) assessment of engineers as part of the 'new petit bourgeoisie'. or Whalley's (1986) characterisation of engineers as 'trusted workers'. Both approaches utilise ascriptive and formal models of class: class position is determined according to a set of assumed physical or cultural attributes and not relationally. This type of sociology tends to consign particular strata within the collective labourer into distinct camps rather than conceptualising different strata within the collective labourer dialectically - an approach which would emphasise changing relationships, alliances and values.

(2) The massive development of the productivity of labour, socialisation of the productive forces, and dramatic rise of corporate and state bureaucracies concomitant upon the development of capitalism. has given rise to the 'collective labourer' as more and more strata of concrete labour become commodified and turned into abstract labour-power. Marx was at pains to demonstrate that the expansion of capital had its corollary in the expansion of labour-power

> Accumulation reproduces the capital-relation on a progressive scale, more capitalists, or larger capitalists at this pole. more wage workers at that. The reproduction of a mass of labour-power. which must incessantly re-incorporate itself with capital ... which cannot get free from capital. and whose enslavement to capital is only concealed by the variety of individual capitalists to whom it sells itself. this reproduction of labour-power forms. in fact. an essential of the reproduction of capital itself (1976: 575-6).

In effect, and contrary to those theorists who posit a growing middle class. Marx highlights how

> in reality, the labourer belongs to capital before he has sold himself - his economic bondage is both brought about and concealed by this periodic sale of himself. by his change of masters. and by the oscillations in the market price of labour-power (1976: 542).

(3) For example. Fincham and Rhodes argue, 'The growing new white collar groups derived their class position not from property but from their employment' (1992: 277). Yet Fincham and Rhodes realise that many 'white collar' jobs are undertaken by women. often part-time. of low status and low pay. They are also aware of the fact that 'white collar' work, is prone to routinisation and de-skilling and that there is growing unionisation of 'white collar' employees (1992: 288). So why define a class in terms of its occupation. in the first place. when it is obvious as Fincham and Rhodes concede. that 'the diversity and fragmentation of white collar groups is now such that they no longer constitute a single class' (1992: 277). Hyman (1983) stresses the range of internal differentiation's in terms of pay, conditions of work, and gendering and clearly casts doubt on the adequacy of categorising occupations in terms of 'white collar', or otherwise.

(4) Marx's primary intention in Capital was to show how surplus-value was pumped out of the direct producers. This necessitated a high level of abstraction i.e. his analysis was pitched at the level of 'pure mode of production'. This does not mean that Marx was unaware of the existence of other classes. far from it. In the 18th Brummaire. he deals in depth with the role of the petit-bourgeoisie. In vol. 3 of Capital. in particular Chapter 15. he examines the different gradations and conflicts of interest that emerge within the 'collective labourer' with the spread of the factory system: the emergence of foremen. supervisors. overseers. skilled and unskilled workers etc.: likewise in his analysis of the development of the joint stock company

he stresses the emergence of 'capital without function' and 'functionaries without capital'. He was also acutely aware of the fact that, in reality, there are no pure modes of production and no pure class

> in actual concrete, historical social formations, modes of production do not appear in their "pure" state, on their own. They are always combined with and stand in complex articulation to, other, previous or subordinate modes of production - which cross cut and over-determine any tendency of "pure" mode to produce a series of "pure" classes' (Marx cited in Giddens & Mackenzie, 1982: 64).

(5) For Weber, the majority of the population are 'negatively advantaged' in that they are forced to survive by the sale of their labour in the market. But the skills, educational qualifications and abilities of people in this position will differ considerably and therefore, for Weber, so will their degree of market power. Whilst Weber follows Marx in attributing crucial importance to private property in class formation he nonetheless views class distinctions as reflections of difference in the size of one's purse. This raises the possibility of a whole series of finely gradated classes and fractions of classes corresponding to an almost infinite number of market income positions. For Marx, however, 'only vulgar common sense turns class differences into differences in the size of one's purse' (1968: 43).

(6) Marx noted that in times of rapid capital accumulation, capital can make concessions to its wage slaves

> A rise in the price of labour as a consequence of the accumulation of capital, only means, in fact, that the length and weight of the golden chain which the labourer has forged for himself allows of a relaxation of its tension' (1975: 232).

(7) Ehrenreich and Ehrenreich argue that a Professional Managerial Class (PMC) has arisen in America comprising one quarter of the population (cited in Walker, P 1982: 14). Gorz argues that there is an 'unbridgeable objective class distinction' between professional, technical, managerial and production workers (1972: 27-28). Poulantzas stresses that a distinction should be made between productive and non-productive workers such as engineers, technologists, foremen and office workers and that these latter groups should no longer be regarded as part of the working class but rather a section of the 'new petit-bourgeoisie' (1973: 78). For Lockwood (1966) an increasing differentiation of the working class is occurring between the 'proletarian traditionalist', the 'differential traditionalist' and the new rapidly emerging 'privatised worker', the latter allegedly holding a 'pecuniary ideology' as opposed to the class, or status ideology of the proletarian traditionalist, or deferential traditionalist.

(8) Poulantzas identifies production relations as having a dual character firstly, a relation between persons and nature (the labour process), secondly, the relation between people (the social relations of production). It is this latter which Poulantzas describes as: 'relations between men and men, class relations' (1975: 10). It is the relationship between producers and the productive forces which, for Poulantzas, 'defines the exploited class in the relations of production' (1975: 19). From this Poulantzas arrives at his general definition of the working class: 'the working class in the capitalist mode of production is that which performs the productive labour of that mode of production' (1987: 20). Poulantzas' identification of the central determinant of class is derived from relations within the labour process; whereas, as Hunt argues, 'it should be insisted that relations within the labour process specify the particular role within the prevailing class relations that various forms of labour perform, but they are not the determinants of those relations' (1977: 29).

(9) As Hunt argues

Is it correct to use Marx's distinction between productive and unproductive labour to define the economic identification of the working class. It is important to note that Marx's thesis concerning productive/unproductive labour are not as unproblematic as Poulantzas suggests (1977: 88).

(10) Marx argues that

> The only worker who is productive is the one who produces surplus value for the capitalist, or contributes to the self-valorisation of capital. If we may take an example from outside the sphere of production, a schoolmaster is a productive worker when, in addition to belabouring the heads of his pupils, he works himself into the ground to enrich the owners of the school. That the latter has laid out capital in a teaching factory, instead of a sausage factory, makes no difference to the relation (1976: 644).

Again

> A writer is a productive labourer not in so far as he produces ideas, but in so far as he enriches the publisher who publishes his works (1969: 213).

(11) Ehrenreich and Ehrenreich (1979) maintain that an objective antagonism between the working class and the PMC exists which has 'undercut the revolutionary chances of the working class' (1979: 43). How can the revolutionary chances of the working class have been cut when the very existence of the PMC is, according to the Ehrenreichs, 'predicated on the atomisation of working class life' (1979: 42-3).

(12) For example, at certain social conjunctures 'profit sharing schemes' have been used by employers to secure worker loyalty and acquiescence to management and the market. Whileyism in America represented a movement of factory committees, works and national councils to secure greater worker participation in manufacturing decision taking (Nichols 1980: 381-394).

(13) In the first phase, Carchedi argues that the function of capital is still carried out by the individual entrepreneur. The employee is merely an extension of the entrepreneur when the latter has to be absent from production. In this respect, he performs the function of capital which is not yet a global function. In this phase, the relationship between the entrepreneur and employee is direct and personal and his place in the division of labour as an executor of the partial functions of capital ensures him a position of privilege and far higher salary than the worker. Finally, for Carchedi, this place in the capitalist production process requires a legal and economic education which ensures that this employee is either petit bourgeois, or bourgeois in origin. For these reasons Carchedi argues that the employee in this phase belongs politically and ideologically to the petit bourgeoisie. During the second phase Carchedi argues that the rise of the joint stock company leads to the appearance of

> that complex organisation, both bureaucratic and hierarchical, within which the function of capital is carried out globally. The transformation of the function of capital into the global function of capital, implies that many of those who perform the global function of capital also perform the function of the collective worker. That is to say, the position of the employee moves further and further away from the entrepreneur and thus ,the personal relation between the two is broken (1980: 256).

Although the employee is no longer an extension of the entrepreneur and his labour-power has been devalued, he is still far from proletarianised in this second phase. Indeed, for Carchedi, the ideology of career making, preferential salaries, terms and conditions and the fact that, 'he still requires a broad culture for the performance of his function' (1980: 256) ensures that the employee identifies his interests with those of the dominant classes, producing a very conservative, 'individualistic lifestyle', through which this employee tries to 'imitate the life style and consumption pattern of the entrepreneur' (1980: 257).

(14) Thompson (1990) identifies four key features of labour process theory: (a) the employment relationship as the basic class relationship, changes here impacting directly on the rest of the economy and society, (b) the accumulation process - competing capitals seeking ever greater rates of profit continually transform the labour process, (c) capital is compelled to increase its control over labour so as to secure surplus-value production, in the context of growing worker organisation and politicisation - forms of control are often complex and varied, nonetheless a 'generalised control imperative' exists within the work process, (d) the employment relationship is a relationship of both co-operation and conflict.

(15) Braverman (1974) argued that the dictates of accumulation compelled capital to seek to reduce the value of labour-power and increase its productivity and that one of the central mechanisms for achieving this was the implementation of 'scientific management' which, through the systematic disassociation of the labour process from the skills of the labourer, the separation of conception from execution of task, and the use of the monopoly over knowledge to control each step of the labour process and its mode of execution, would effectively place control in management's hands.

(16) In effect, the ebb and flow of capital into and out of different branches of production, should caution one against making glib assumptions about capital's universal tendency towards de-skilling. When capital opens up a new branch of production new skills may emerge but one profit rates tend to equalise out within this branch of production, then capital may adopt a more vigorous strategy of rationalisation seeking to recoup falling profitability through strategies of labour intensification and de-skilling. Obviously, its capacity to do so will be contingent upon the respective balance of class forces and the degree of organisation of labour within respective branches of production.

(17) Once capital purchases labour-power it needs its co-operation if production is to take place. Otherwise, too much time, effort and money would be wasted on means of coercion, surveillance and administration leading to possible absenteeism or simply withdrawal of consent on the part of the workforce, for example, in the areas of materials handling, quality checks, maintenance and repair. Thus, whilst playing its part within any capitalist labour process, coercion alone, is an insufficient and costly means of organising labour-power (Burawoy 1979).

(18) This argument finds parallels in the work of Weiner (1981) who argues that a dominant anti-productivist culture permeates the British ruling class which look down on manufacturing and those engaged in it. The argument is that a specific section of the ruling class located within landed and financial capital were, through their political and cultural hegemony, able to oversee the process of industrialisation and ensure the perpetuation of a dominant aristocratic culture. The public school system is seen in this model as an institution for incorporating the sons and daughters of wealthy, predominantly northern industrialist magnates, into the dominant aristocratic culture. Armstrong (1989) utilises Fox's (1974) theorisation of power and trust to argue that British management is a high trust, high discretion job, whereas productive activity - due to the peculiarities of the British society discussed by Weiner, is a low trust low status job. In effect, Armstrong draws exactly the opposite interpretation of engineers to Whalley *viz.* they are not trusted by senior management.

Methods

(1) A useful way of summarising the debates about positivism and anti-positivism in social science is contained in the table below. Obviously these are idealised versions and in practice degrees of overlap will occur:

	Positivist	Anti-Positivist
Ontology/epistemology	Social reality exists as objective casual relations between phenomena	Social reality is a product of meaningful social interaction
Methodology (i) Defining reality	Observational constructs in order to hypothesise about causal relations between variables	Actor constructs
(ii) Process of validation	Testing of hypothesis by use of quantitative evidence	Understanding through the apprehension of qualitative evidence
(iii) Form of explanation	Empirically valid statement about law-like causal relationships between variables	Meaningfully intelligible descriptions of how social life is accomplished.

Table 3. Positivist and Anti-Positivist Methodology

Bilton et al argue:

> The logic underlying the positivist sociological explanation of social reality is based on a desire to measure quantitatively the extent of a relationship between phenomena, and in so doing to match the rigour of the laboratory experiment in other sciences, and to provide general law like propositions about social reality (1987: 511).

By contrast anti-positivists tend to split into two camps:

> There are those who feel that once one has avoided imposing categories on the subject matter at the discovery and validation stages and has understood the actors way of looking at the world, one is then in a position to provide an objectively valid explanation of the nature of this socially constructed reality. Max Weber was an important exponent of this view......However there are others who claim that such objectivity is impossible. From this point of view the only sort of explanations that sociologists can provide are subjective: reflexive or retrospective accounts of how, as meaning attributing individuals, they arrived at their particular understanding of some specific social situation (Bilton et al 1987: 514-515).

Giddens (1985) tries to address the notion of structure and agency so central to debates on sociological methods by attempting a synthesis which challenges the theoretical division between 'hard' and 'soft' positivism with their mutually exclusive ontology's, epistemologies and methodologies. Giddens argument is that social reality cannot be conceptualised in terms of a 'pre-given universe of objects' open to some 'independent' or 'context free' observer. Rather it can only be understood as the ongoing product of actors consciously creating their world. At the same time these actors are, however, constrained by the structural conditions in which they live so that although 'men produce society' they do so 'not under conditions of their own choosing'. In other words there is a dialectical relationship between structure and action.

(2) Sayer argues that:

> Scientism uses an absurdly restrictive view of science, usually centring around the search for regularities and hypothesis testing, to derogate or disqualify practices such as ethnography, historical narrative or explorative research, for which there are often no superior alternatives (1992:4).

Indeed in the 1960s sociology was growing rapidly as a subject discipline receiving considerable support from government who thought this new social '*science*' would help the state to fashion more effective and enlightened social policies (Bilton 1987). As part of this process the government established the Social Science Research Council (SSRC) in 1966. However, at the very time when social science had established its credibility as a discipline based on 'sound scientific principles' developments in sociological theory, primarily about the relationship between structure and action along with developments in neo- Marxism led many to reconsider the subjects 'scientific' status. Consequently, in 1985 at the behest of Sir Keith Joseph the SSRC was renamed the Economic and Social Research Council (ESRC) the word 'science' conspicuous only by its absence. Government funding has also been cut back dramatically for the ESRC and this has prompted further heated debate within the social sciences between those who seek to restore the disciplines 'scientific' ethos through adopting increasingly quantitative and mathematical approaches within a positivist ontology and methodology and those who have declared the sterility of the debate and decided to draw upon a wide range of research methods without feeling one has to discuss the sort of methodological assumptions their use implies (Bilton 1987). The notion that science can be assumed to be the highest form of knowledge and that other types of knowledge are dispensable or displaceable by science has been challenged (Sayer 1992, Pinch & Bijker 1987). Knowledge cannot be regarded as a thing or product which can be evaluated independently of any consideration of its production and use in social activity. As Sayer argues:

> The word science needs special comment. There is little agreement on what kinds of methods characterise science beyond the rather bland point that it is empirical, systematic, rigorous and self critical, and that disciplines such as physics and chemistry are exemplars of it. Most users of the term obviously consider it to have strong honorific associations that few are willing to cede to opponents...[yet]....the time when science was thought to involve the steady accumulation of objective knowledge through a neutral medium of observation has long since gone (1992: 7-8).

(3) Hammersley and Atkinson argue that,

> The most important feature of scientific theories is that they are open to, and subject to, test: they can be confirmed, or at least falsified. This process of testing involves comparing what the theory says should occur under certain circumstances with what actually does occur; in short comparing it with 'the facts'. These facts are collected by means of methods that, like the facts they collect, are regarded as theory neutral; otherwise it is assumed they could not provide a test of the theory. In particular every attempt is made to eliminate the effects of the observer by developing an explicit, standardised set of experiment or interview procedures. This allows replication by others so that an assessment of the reliability of the findings can be made (1983: 5).

Naturalism's response to this positivist scientific method was to assert that the researcher should study the social world in its natural undisturbed state and not in artificial settings like experiments or formal interviews. Furthermore the researcher should carry out the research in ways that are sensitive to the nature of the setting even to the extent of going 'native' i.e. totally immersing oneself in the culture, values and lifestyles of the group one is studying. Both positivist science and naturalist science assume that it is possible, in principle at least, to isolate a body of data uncontaminated by the researcher, either by turning him or her into an automaton or by making him or her a neutral vessel of cultural experience. However, searches for empirical bedrock of this kind are futile; all data involve theoretical assumptions (Hammersley & Atkinson 1983: 14).

(4) For example, there is heated debate in the natural sciences regarding how the risks associated with exposure to radiation are to be identified and assessed. Disagreement over this results in the fact that the measure of the risk of cancer varies by a factor of ten between the USA and Britain. This is despite the fact that both countries vigorously defend their own models of risk assessment.

(5) There is heated debate as to which methodological approach is most appropriate in sociological research. The table below indicates the relative strengths and weaknesses of the four main research methods:

Research method	Strengths	Limitations
Fieldwork	Usually generates richer and more in depth information than other methods. It also provides flexibility for the researcher to alter strategies and follow up new leads that may arise.	Can only be used to study relatively small groups or communities. Findings might only apply to the groups or communities studied.
Surveys	Make possible the collection of data on large numbers of individuals.	The material gathered may be superficial. Important differences between respondents viewpoints may be glossed over. May not convey an accurate impression of what people actually believe.
Documentary Research	Can provide sources of in-depth materials as well as data on large numbers and is often essential when a study is wholly historical.	The researcher is dependent on the sources that exist which may only be partial. It can be difficult to interpret how far they represent real tendencies - as in case of some kinds of official statistics.
Experiments	The influence of specific variables can be controlled by the investigator and are usually easier for subsequent researchers to repeat.	Many aspects of social life cannot be brought into the laboratory and the responses of those studied may be affected by their experimental situation.

Table 4. Four Main Methods Used in Sociological Research

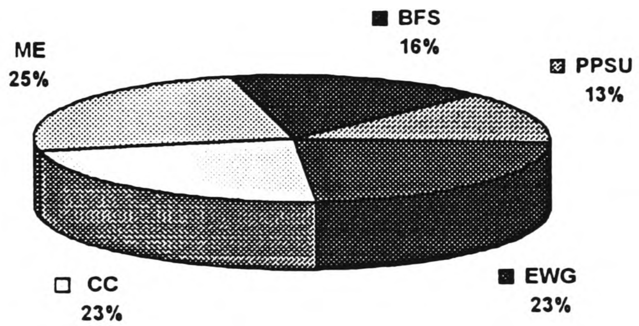
(6) I interviewed over 300 respondents in over 60 organisational settings. In turn many of these interviewees were also directly observed in field studies and subsequently re-interviewed in the light of gains in knowledge and understanding brought about through fieldwork. This offsets one of the chief objections to ethnographic study i.e. that sample sizes are too limited

to make useful claims about them. I must emphasise that this research involved *intensive* interviewing. This coupled to more detailed case study involving participant observation enabled me to build up not only a rich picture of analysts work culture but also to make useful cross referral and cross cultural comparisons, for example, between the work of engineers and analysts.

(7)

Type/Duration of Access	**No. of Organisations**
Wide access to staff for at least two months	7
Limited access to staff for up to two months	11
Restricted access to staff over several months	11
Remaining organisations accessed on a more limited scale due primarily to time constraints	32
Total	61

Table 5. Type of Case Study Access and Number of Organisations.



Public Or Private Sector Utility (PPSU)	8
Electrical Or Electronic White Goods (EWG)	14
Computing Software/Hardware/Consultancy (CC)	14
Manufacturing Or Engineering (ME)	15
Banking/Financial Services (BFS)	10
Total	61

Table 6. Sectoral Location Of Organisations Accessed.

(8)

Union Officers (UO)	35
Senior Managers (SeM)	39
IT consultants (ITC)	11
IT Directors (ITD)	4
Systems Managers(SyM)	46
Project Managers(PM)	17
Senior Systems Analysts (SSA)	12
Systems Analysts/Developers (SAD)	62
Programmers (P)	22
Production Engineers (PE)	4
Industrial Engineers (I.E.)	6
Chief Design Engineers (CDE)	5
Electrical/Electronic Engineers (EEE)	14
Mechanical Engineers (ME)	12
Software Engineers (SE)	17
Total Number of Interviewees:	306

Table 7. Interviewee Number and Type

(9) Refer to Appendix : Checklist of Questions.

(10) I was assisted on three separate occasions by undergraduate students. One who was on work placement with me during the summer of 1992 and who attended seven interviews with me and helped take notes and ask questions; and two whose Honours projects I was supervising. These students were doing fieldwork for me as part of their Honours projects. These projects were set up by me and I was their main supervisor. Their projects overlapped with my own research on design. They were involved in arranging and conducting interviews and case studies of their own. On five occasions these students also assisted me whilst interviewing - taking notes and asking questions.

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